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THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF THE INSTITUTE OF BRITISH FOUNDRYMEN; THE WELSH ENGINEERS' AND FOUNDERS' ASSOCIATION, AND THE FOUNDRY TRADES EQUIPMENT AND SUPPLIES ASSOCITION.

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Foundry Facings.

We have recently had the opportunity of examining a number of analyses of coal dust, and patent blackings, and whilst comment is made at some of the high ash content, we can assure the industry that on an average they are some 50 to 75 per cent. better than a similar series made about 1912. Whereas 50 per cent. is the highest ash content reported in the present series, 75 and 80 per cent. were common in the earlier work. For plumbago, too, there has been a similar improvement. Much, however, remains to be accomplished before foundry facings attain the definiteness which ought to be their main attribute.

It is primarily desirable that the foundry industry should tell the manufacturers of facings what they require, as the latter are not in a position radically to depart from what years of experience has taught them fills the market. The ash content of plumbago consists mainly of clay, added to make it adhesive. This, of course, can be extended to be nothing more or less than an adulteration, and various important firms and research organisations have instituted specifications. The Falkirk Technical Institute consider 10 per cent. of ash as being the maximum necessary, whereas a very large firm in the North Midlands allows 15 per cent. both for plumbago and coal dust.

Metallurgists have developed two theories pertaining to the action of coal dust, the correctness of which will modify slightly the requirements to be expected from the material. The older conception insists that the volatile matter evolved from the coal dust forms a gaseous blanket, which prevents more or less efficiently, the fusing of the oxide of the skin of the rising molten iron with the silica of the sand mould. This conception allows of a chemical expression, and practical support can be lent to the theory by overloading sand with coal dust of high volatile matter content, when blown castings can be produced. The other theory, which we have never seen published, relates to the porosity of the coke which is left. This mechanical conception, we take it, is a microscopic edition of the cinder beds used for venting large moulds. This would demand, happily, a coal dust of somewhat similar character to the former, but of course stress would be laid upon the porosity of the coke.

If a mechanical explanation could be generally accepted it would be preferable, but we feel sure, that at the moment, the majority of foundry metallurgists favour "the imposition of a blanket of reducing gases (coal gas) between the oxidised skin of the metal and the fusible elements of the sand" theory as being the more helpful.

The mechanical conception that coal dust should open the sand, by the formation of larger volume of coke is interesting, but if it helps the permeability of sand in this way, it *must give the passages through the sand much more work to do*, by causing "congestion of the lungs," through the evolution of the volatile gases, which will occupy several hundred times the volume of the swollen coke. Again, the very swelling of the coke must compress the sand or at least reduce the pore-space-area. As we have never had a well thought out exposition of the mechanical theory, we should welcome one, as in general they are preferable to those based on chemistry. For instance, Mr. Hurst, elsewhere in this issue, shows how "growth" in cast iron can be partially explained on purely physical grounds.

We again congratulate the manufacturers of foundry facings on the progress they have made, and would urge them to collaborate with the foundry industry with the object of supplying to chemical and perhaps physical specifications.

Correspondence.

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

The Venting of Moulding Sands.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—My friend, Mr. Longden, in his letter published in your last issue, indicates a certain confusion of the points at issue. Venting is an artificial means adopted by the moulder in order to make up for the lack of permeability possessed by his moulding sand. Venting has, therefore, nothing to do with permeability. If moulding sands were really porous to gases there would be no need for any venting at all.

Although I, like everyone else, constantly observe gases burning on the outsides of moulds, I have no evidence of this happening when and where the sand possesses no artificial channels, such as those provided by vent-wires, mould-joints, and so on. I speak of moulds where the sand is three or more inches in thickness.

A research upon the passage of mould gases through ordinary moulds (green sand or dry sand) would provide, I think, good reasons for a change in the popular conception of what happens.

The moulder may believe that these gases go through the pores of the sand, but the evidence of their doing anything of the kind to any practical degree is, to my mind, remarkable by its absence. I am willing to be convinced, however, and it is a most interesting subject.—Yours, etc.,

HORACE J. YOUNG, F.I.C.

16, Ashfield Grove, Whitley Bay,
Northumberland.
July 10, 1925.

The Practice and Purpose of Perlit Iron.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In his letter, published in your issue dated July 9, Mr. A. Marks asks three questions, the first two being:—

(1) What moulder could core up a complicated mould at a temperature of 200 deg. or even 100 deg.?

(2) What moulder would risk transferring a mould—say, a Diesel cylinder head mould—after coring up at ordinary temperature, to the stove to be heated up to 200 deg. C., and then withdrawn and cast?

His queries are answered by the simple statement that, twice or thrice weekly, we are casting, under Perlit Process conditions, many castings of all shapes and sizes, including heavy and intricate Diesel castings. That Mr. Marks has no previous working knowledge of the procedure, and, therefore, does not know how it is worked, is precisely the position in which I myself stood at the beginning of this year.

His third query reads:—

(3) How many members are aware that pig-iron has been produced since 1920 with a composition specially designed for making *pearlitic* iron at a low cost not 100 miles from Glasgow?

Personally, I did not know that which Mr Marks states. I can inform him, however, that, in the foundries of The North-Eastern Marine Engineering Company, under my direction, it has been the custom, for the past ten or more years, to make pig-iron of this description. The making of pig-iron to produce *pearlitic* cast iron has no bearing upon the making of Perlit iron; indeed, the latter would need a different pig-iron.

His final remark is:—

(4) "At Cardiff, when reading my Paper on 'High Tensile Cast Irons,' I showed samples of 3 in. diam., all pearlitic, and also under the microscope two samples taken from large pieces of *pearlitic* cast iron."

Mr. Marks refers to a Paper he read in December, 1924; but before the Institute of Marine Engineers on January 22, 1922, I showed precisely the same things, and Figs. 8 and 10 of that Paper, entitled "The Problem of Grey-Iron Castings," remain as proofs. As a matter of fact, we have dozens of such photographs taken in the course of daily routine, but it is difficult to see what bearing they have upon Perlit iron. Mr. Marks must not confuse Perlit iron with pearlitic structure, as he understands it, and as we have all understood it until we saw the peculiar structure and properties of the metal produced under Perlit Process conditions.

Mr. Marks proves, by his questions 1 and 2, that he is unfamiliar with this new process; while his third question and his final remark prove an equal unfamiliarity with the effects of that process upon the material produced thereby. His continual reference to *pearlitic* iron, apparently under the assumption that what he is talking about is the same as Perlit iron, is an entire misapprehension of the facts of the case. By composition, structure and physical properties, Perlit iron and Perlit-iron castings are different from ordinary ones. For years we have made pearlitic iron, but only during the past few months have we made Perlit.

I propose to deal with all further points when publishing a written reply to the discussion of my recent Paper on the subject.—Yours, etc.,

HORACE J. YOUNG, F.I.C.

16, Ashfield Grove, Whitley Bay,
Northumberland,
July 10, 1925.

Foundry Technical Institute, Falkirk.

To the Editor of THE FOUNDRY TRADE JOURNAL.

SIR,—In your issue of June 25, in the note on Mr. A. Campion, on p. 556, you state in reference to the above Institute, "trade depression led to the abandonment of the scheme in 1922."

I do not know where you can have obtained such information, but as it is entirely incorrect and misleading and prejudicial to the interests of the Institute I shall be glad if you will make it known that the scheme, so far from having been abandoned, has since the date mentioned been carried on with marked success and benefit to the light castings trade in Scotland, under Mr. Hy. Cowan as superintendent.—Yours faithfully,

J. C. JEFFREY SMITH,
Chairman of Ironfounders' Committee
of the Foundry Technical Institute.

The Camelon Iron Company, Falkirk.
July 10, 1925.

[Obviously, we were aware of the excellent work being carried out by the Falkirk Technical Institute under the able direction of Mr. Cowan, and we regret that a junior should have inserted this in our absence.—ED.]

Leaky Cylinders—a Recipe.

Many leaky cylinders are condemned to the scrap-heap when there is really no need for such a drastic course. In many cases, though not in all, leakage is caused by nothing more than open-grained metal. When a cylinder has been tested and found to leak special care should be taken in examining the metal around the leakage. Should the metal be open-grained, the following remedy should attain much success. Give the cylinder a thorough cleaning, removing all dirt, dust or accumulated sand. A saturated solution of hydrochloric acid and iron-drillings should then be obtained (the drillings should be perfectly free from rust). The interior of the cylinder should then be washed with this solution for five or ten minutes. Ammonia water is then applied, and the inside of the cylinder subjected to air pressure or a steady flow of steam. This will drive the iron hydroxide into every pore of the cylinder walls. The cylinder should then be allowed to dry naturally.

The International Foundry Trades Exhibition, 1926.

The preliminary prospectus of this exhibition which is to take place at the Royal Agricultural Hall, Islington, from June 10 to 19 next year, and which has the patronage of the Institute of British Foundrymen, is now available on application to the organisers, Messrs. F. W. Bridges & Sons, Limited, Avenue Chambers, 4, Vernon Place, Southampton Row, London, W.C.1.

Weighting Moulds.

BY "PRACTICIEN."

Many defective castings are the result of either over-weighting or under-weighting the mould. It is surprising that such an important matter as this should be left to "rule of thumb" by many ironfounders. Perhaps this is due to insufficient theoretical knowledge.

Upward Pressure of Molten Metal.

The upward or lifting pressure of the molten metal being poured into the mould depends directly on the head-pressure and the weight of the top-part liable to be floated by the metal. It has often been said that a weight heavier than the casting itself is the correct method of weighting the mould. The following example will easily show that this is not quite true. In a tank-plate mould, suppose the thickness of the plate is 1 in. Next to it there is a similar mould, the thickness of the plate in this instance being 2 in. Both moulds have the same head-pressure (the distance from the runner to the top of the plate), and both are run under the same conditions. According to the foregone rule, the second mould should have twice as much weight on it as the first one. It can be easily understood that this is not so,

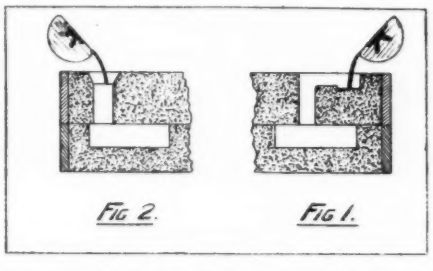


FIG 2. FIG 1.

and were the rule applied the mould may suffer from over-weighting.

Sunk Cores.

Take the instance of a simple block casting with a sunk or submerged core, chaplets being used to keep the core from rising, the weight being placed on top of the chaplets and supported at the ends. Assume the core to be 20 in. long, 9 in. wide, and 7 in. deep, its ends being free. The cubical contents are then 1,260 cub. in., or a weight of 328 lbs. of metal displaced by the core. The weight of the core itself is 1,260 × 0.06 (0.06 being the weight of 1 cub. in. of rammed sand) or 76 lbs. The buoyancy of the core would thus be 328 − 76 = 252 lbs., which is the weight required to keep the core from rising. Had the core, of course, been supported by prints instead of being free at each end, its additional length and the sand over the prints would have to be deducted from the 252 lbs. Suppose the weight of the cope to be 400 lbs. and the area of the casting surface 300 sq. in. This area is multiplied by the height of the gate in inches, say 7 in., giving 300 × 7 = 2,100 cub. in. Multiplying this by 0.26 we get 546 lbs., the fluid pressure tending to lift the cope. Deducting from this the weight of the cope (400 lbs.) gives 146 lbs., the weight necessary to hold down the cope alone. This, added to the weight necessary to hold down the core (252 lbs.) gives 398 lbs., which is the total weight to be placed on the cope.

Partially Sunk Cores.

In some cases cores are only partially submerged, their upper surfaces being in direct contact with the cope. To determine the pressure on such a core, first calculate the lower surface area of the core, and also the area of the portion of the cope which has metal beneath it. Then multiply each of these results by the distance to the top of the highest point to which the metal rises in pouring the mould.

General Rules.

The lifting pressure or static pressure on a sunk core is the number of lbs. of iron it displaces minus the weight of the core. If the casting is lifted out by the cope, the projecting sand may be considered as a core, and the lift calculated as already shown. Should the casting itself project into the cope, the following method is found to be practically accurate. Determine the area, in sq. in., of each surface in contact with the underside of the cope; multiply this by the distance in inches from the surface mentioned to the top of the pouring basin, and then by 0.26. Repeat for all surfaces and add together. The total will be the actual lift exerted. For inclined or curved objects the pressure is computed on their projected area, that is, on the area of the surface covered by them, as viewed in plan. The head is determined from the gate down to a point half-way between the highest and lowest parts of the object, measured on a vertical line.

Extra Weight Due to Other Conditions.

While it is true that the foregoing rules for weighing down copes are correct under simple conditions, there are other numerous conditions affecting the result and which will very often demand more weight than that given by the rules. The above is due to the fact that a sudden pressure is exerted when the metal comes in sudden contact with the lifting surface. This sometimes calls for ¼ oz. or even ½ more weight on the cope than the static-pressure obtained by rules just given. It will be easily seen that the higher the top of the pouring gate is above the lifting surface of the cope, the greater will be the extra exerted pressure. Again, some castings are with two, three, four or more runners. This again calls for more weight. A gate, however, as shown, in Fig. 1, would require less weight on the cope than a "direct drop" gate as in Fig. 2.

Momentum Lift.

Momentum lift is caused by the sudden stopping of the inflowing iron, that is, when the mould is filled. Extra weight must be allowed for this, though, however, it is governed briefly by the system and speed of pouring, the number of ladles, and the amount of lifting area which the metal will suddenly rise up against, as well as the height of the flow-off risers in relation to the pouring gate. Care must be taken to place more weight on the cope than is given by rule.

Dull Iron and its Effect on Buoyancy.

If a mould is poured with dull iron, less weight is generally put on the cope, the theory being that less pressure is exerted due to less fluidity of the metal. This, however, does not hold good. In moulds having flow-off gates, the pressure is apt to approach that due to the height of the pouring basin. Sometimes the metal will set at the entrance to the risers, or it may enter the risers so sluggishly as to stop the flow of metal out of them, and so gain a high head-pressure. In thin castings, however, this hardly applies, and no great importance should be attached to such cases.

Calculating the Head-pressure.

In calculating the head-pressure on the cope many moulders make a big mistake, which sometimes results in serious consequences. The height is taken from the top of the riser. To say the least, this is rarely a safe practice, as risers may set or be blocked up. Were it possible always to rely on good hot metal with a perfect flow throughout the mould, this method would be practicable. This, however, is not safe to rely upon, and the only safe plan is to work from the highest point it is possible for the metal to reach in the gates or risers, and then allow extra weight on the cope.

Weights Used for Holding Down Copes.

There are several kinds of weights used for holding down copes, but box weights of a handy size are recommended. The weight should be cast or stencilled on, as much time is thus saved. In foundries where repetition work is carried out separate weights should be allowed to each box and a table of weights required for each type of castings made, hung in a prominent part of the shop.

Clamps for Turnover Work.

In shops where turnover work is employed it is advisable to have a number of clamps especially adapted for their jobs. Some are of cast iron and

others of wrought iron. Many moulders frequently try to clamp boxes by driving wedges at the top of the clamps. This is totally wrong. A constant jarring takes place in lifting the weight of the clamp, making it difficult to get the clamp to a solid bearing. Considerable loss of time is also involved. For heavy work wrought-iron clamps should always be used. To obtain the safe thickness of clamps, calculate the pressure on the flasks to be held together, and determine the distance apart that the clamps well placed on the flange of the box. Allowing a stress of 15,000 lbs. per sq. in. for cast iron and 5,000 lbs. per sq. in. for wrought iron, a good idea of the required strength of the clamp can be formed. In clamping boxes before casting it is not wise to drive in wedges with a hammer, as this will jar the cope and cause the sand to drop. In closing commendation may be given to the practice of using bolting-down floors instead of weights. In repetition foundries this method is gaining extensive favour, but for jobbing foundries such a method would not meet with much success.

The Selling of Castings.—XIV.

By VOYAGEUR.

A Publicity Department that confines its efforts solely to the British Isles when the castings with which it deals have a large Continental or world-wide sale, is not reaching its maximum efficiency. Nor does its work end with the mere designing and placing of advertisements. It has, if it be an efficient department, to see that its branch offices, agents, and travellers, in all parts of the country and of the world, are supplied with everything they need to enable them to sell more goods and to sell goods more readily, and to see that they are kept closely in touch with the policy of the publicity and sales campaigns.

One of the first steps that should be taken is to provide every agent and every traveller with a complete or "master" set of every catalogue, pamphlet or folder issued. This enables them to see at a glance just what literature is available concerning the foundry and to order fresh supplies as and when these become necessary. Whenever a revised or amplified edition of any catalogue, etc., is issued, a specimen should be sent to each agent and traveller with instructions to substitute it for that which previously figured in the "Master Set." New literature should be added in the same way. If it can be afforded, a good plan is to design a light wooden cabinet to contain the whole set. This cabinet should be provided with thin suitably-spaced partitions for the different sizes of booklets, and should have a "roll-top" cover which can be drawn down over the whole to prevent an accumulation of dust. On the base of the cabinet can be painted the name and address of the respective agent, or any other wording. Issued to the agents and branch offices, they will ensure the careful preservation of the set, and also serve a useful publicity purpose.

Copies of all advertisements that contain selling points, or new copy-angles, should be sent to every agent and traveller. Pulls can be obtained from the printers and distributed. Sometimes, too, it is advisable to keep an eye on competitive advertising, and where any new claims are advanced for rival goods, to make copies and forward them, together with the argument against the claims, to each salesman and agency. In this way representatives learn the qualities and characteristics of the castings which they have to sell, and also learn to meet competition. They are provided not only with new talking-points, but also with accurate details of their opponents' case, invaluable information when a big contract is in view.

If a house-organ is published, agencies and branch offices should be invited to contribute articles of special interest to users of the product in their own territory, or to suggest features that would be well received. All mailing lists for customers and prospects in their territory should be submitted to them periodically for revision, amplification, and excision. No catalogues or booklets should be sent to prospects in their districts without a copy of the enclosing letter being sent to them. In many cases it will be found advisable to hand the letter over to them to be forwarded or not as they may deem advisable.

The co-operation of the agency in foreign and colonial advertising is highly desirable. American branch offices usually prefer to place and design their own advertising, for the reason that the copy needs a somewhat different twist and the media, careful selection on the spot. Continental agencies should be consulted as to the best journals in which to advertise the product, and the publicity department, with the list in their possession and specimen copies of each journal at hand, should prepare suitable copy and lay-outs. These should then be sent to the agent as a series, for translation into the appropriate language. This done, the agent should forward the copy to the respective journals, have the whole series set up in type, and then send the completed proofs to the advertiser for examination, after he himself has checked the printing errors in the copy. When finally O.K'd, they should be returned and published. This procedure is, of course, necessary only when the agency has no specialised knowledge of or interest in advertising. If the agency prefers to design and write its own advertisements, these should be closely watched to increase the efficiency of advertisements.

There are many little points which, if carefully observed, may, though insignificant in themselves, do a great deal towards increasing the business of the agency. For instance, every reply to a direct request for literature or information from a foreign or colonial correspondent should mention the name and address of the nearest branch or agency office. This is not only a convenience to the correspondent, but also serves to introduce the agency to him. The agent's name and address should always be inserted somewhere in the supplies of literature sent to him for distribution among his friends and customers. This is not an expensive matter, and can easily be arranged with the printer when supplies are being run off.

Framed photographs of the works or of exceptionally big jobs are always welcomed by branch offices and agencies. They are usually hung on the walls of the office, and in addition to being seen by sellers at all times of the day, will often serve to point an argument in the negotiations precedent to the placing of an order. Showcases containing test pieces of the castings or showing them in their various phases of manufacture are also useful. In addition to the purposes above-mentioned, there are often handy things to send to some local exhibition or fair, when the cost of sending castings from England would be almost prohibitive, or the danger of damage during transit be great.

Advertisements placed by the publicity department in journals which have a wide circulation in the agent's district should always give his name and address.

Attention to apparently trivial details like this has a cumulative effect, the influence of which is shown eventually in increased sales, increased profits, and in the increased willingness of the agent to do his share in making the advertising a success.

Iron and Steel Production in June.

The production of pig-iron in June amounted to 510,300 tons compared with 574,700 tons in May and 607,800 tons in June, 1924. The furnaces in blast at the end of the month numbered 148, a net decrease of 9 since the beginning of the month, and a decrease of 37 compared with the number in blast at the end of June, 1924.

The production includes 134,700 tons of hematite, 179,000 tons of basic, 139,100 tons of foundry and 24,600 tons of forge pig-iron.

The production of steel ingots and castings amounted to 585,400 tons compared with 651,600 tons in May and 651,600 tons in June, 1924.

MESSRS. H. JAYES AND E. H. JAYES, ironfounders and general and heating engineers, Little Holme Street, Leicester, trading under the style of Henry Jayes & Son, have dissolved partnership.

The Heat Treatment and Volume Changes of Grey Cast-Iron.

By J. E. Hurst.

The behaviour of grey cast iron when exposed to varying temperatures for more or less prolonged periods of time is a subject of considerable industrial importance. In some of its most important applications, for example, internal combustion engine pistons and liners, superheated steam fittings and similar items, grey cast iron is called upon to sustain conditions of considerable temperature.

The phenomena associated with the effect of high temperature conditions on cast iron have been extensively studied during recent years by Hatfield, Carpenter and Rugan, Hurst, Donaldson and

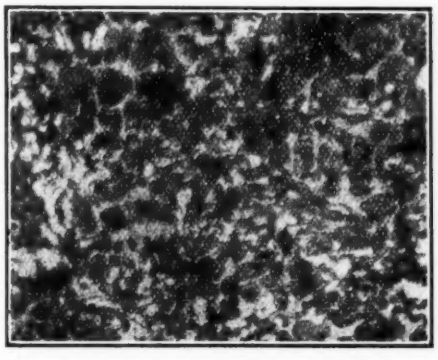


FIG. 1.—AUTOMOBILE ENGINE PISTON FROM GUDGEON PIN BOSS. ETCHED × 100 DIAS.

many others in this country. As a result of these investigations the changes which take place in cast iron on subjection to various temperatures are now more generally understood.

Constitutional Changes on Heating Cast Iron.

The constitutional changes taking place on heating cast iron would be expected to be the reverse of the changes taking place on the cooling. Whilst this is strictly true, there are certain other phenomena incidental to the reheating of grey cast iron which are apt to confuse the experimental proof of this. Cast iron when reheated to temperatures above the pearlite change point reabsorbs a portion of the graphitic carbon, and if quenched from these temperatures, retains the re-dissolved graphite in the austenitic or martensitic form. It is not always easy to show this, and the rapidity with which the free carbon is re-absorbed appears to depend to some extent on the character of the free graphite. For example, the free graphite in an annealed malleable casting in a very finely divided form rapidly re-dissolves, whereas the coarse graphite in a No. 1 pig-iron is extremely difficult to re-dissolve. This appears to be due in a large measure to the penetration of furnace gases into the cast iron by way of the coarse graphite plates and also to the rate of heating which determines the local expansions of the cast iron in the neighbourhood of the graphite plates. These factors reduce and destroy the intimate contact between the graphite and the surrounding metal matrix, which at once prevents the re-absorption. With careful heating reabsorption of the carbon in such cases can be carried out *in vacuo*.

On cooling down slowly, re-absorbed graphite is reprecipitated and further graphite is reprecipitated from any solid solution remaining in the cast iron. The early research of Hatfield[1] showed that the exposure of ordinary grey cast iron containing silicon to a high temperature resulted in the conversion of the combined carbon into graphite. Bars containing 2.14 per cent. silicon and 0.54 per cent. C.C. exposed to a temperature of 900 deg. C. for several hours and cooled slowly over a period of 48 hours showed a reduction in combined carbon from 0.54 per cent. to 0.18 per cent., accompanied by a corresponding increase in the graphitic carbon.

Decomposition of Carbides by Heat Treatment.

It was shown by Charpy and Grenet,[2] and later confirmed by the writer,[3] Donaldson[4] and certain American workers, that the conversion of combined carbon to graphite takes place in cast iron even when subjected to temperatures considerably below the pearlite transformation point. The effect of subjecting a series of bars of ordinary foundry irons of varying silicon content to a temperature of 575 to 600 deg. C. for a period of 150 hours is shown in Tables I and II.

TABLE I.—*Chemical Analysis before Heat Treatment.*

Test No.	CC.	Gr.	Tot C.	Si.	Mn.	S.	P.
0.0	0.78	2.75	3.53	1.14	0.31	0.041	0.45
2.0	0.88	2.71	3.61	1.16	0.30	0.040	0.45
3.12	0.65	2.83	3.48	1.44	0.49	0.17	0.84
4.15	0.75	2.69	3.44	1.47	0.50	0.17	0.84
5.10	0.62	2.74	3.36	1.58	1.02	0.13	1.04
6.13	0.38	2.66	3.04	2.69	0.33	0.15	1.40
7.16	0.39	2.69	3.08	2.69	0.32	0.16	1.45
8.14	0.67	2.48	3.15	2.46	0.36	0.16	1.32

TABLE II.—*Carbon Contents after Heat Treatment for 150 Hours.*

Test No.	CC.	Gr.	Tot C.
0.0	0.54	3.02	3.56
2.0	0.90	3.47	3.37
3.12	0.23	3.20	3.43
4.15	0.70	2.78	3.48
5.10	0.50	2.88	3.38
6.13	0.10	3.06	3.16
7.16	0.14	2.89	3.03
8.14	0.13	2.92	3.05

This reduction in combined carbon content at temperatures below the pearlite point is a somewhat unexpected phenomenon and has been amply confirmed by other investigators. In ordinary cast irons, other things being equal, the ease with which the combined carbon is decomposed appears to depend upon the silicon content. In mild steel containing very small amounts of silicon, annealing at temperatures below the pearlite point for indefinite periods of time is unaccompanied by any decomposition of the combined carbon. In malleable cast iron containing less than 1 per cent. silicon it is impossible to bring about decomposition of the combined carbon at these low temperatures. The above results confirm this that the

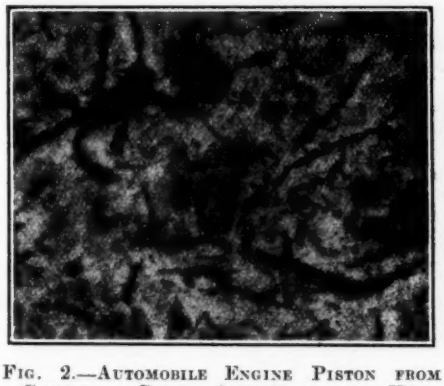


FIG. 2.—AUTOMOBILE ENGINE PISTON FROM CENTRE OF CROWN AFFECTED BY THE HEAT. ETCHED × 100 DIAS.

higher the silicon, the greater the extent of the decomposition of the carbide.

In addition to being dependent on the silicon content, this phenomenon is also dependent on the temperature and the duration of the heat treat-

[1] Hatfield, J.I.S.I., 1907.
[2] Charpy, Engineering.
[3] Hurst, Engineering, July 4, 1919.
[4] Donaldson, I.B.F.

ment. This has been conclusively demonstrated by Donaldson, who clearly showed the decomposition of the combined carbon at the lower temperatures of 450 deg. C. and the increase in the extent of the decomposition at this temperature with increase in the duration of the heating.

After 150 to 200 hours' heating at this temperature the decomposition is almost complete, or more rather reaches a point at which further prolonged heating is accompanied by very small changes in the combined carbon content. In a like manner the minimum temperature at which this decomposition of the combined carbon is brought about has not been determined, but it is highly probable that at low temperatures this change takes place with infinite slowness.

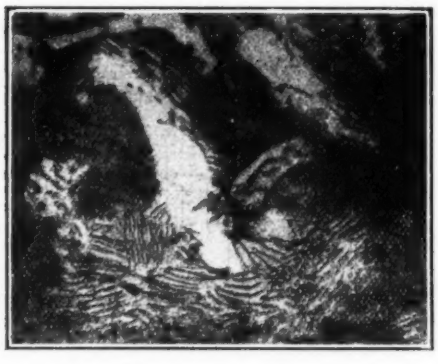


FIG. 3.—GREY CAST IRON × 550 DIAS.

A further important conclusion appears to be justified that the extent of the decomposition of the combined carbon is independent of the initial quantity of combined carbon present in the iron for any given duration and temperature conditions of heat treatment. It would appear that under given heat-treatment conditions the combined carbon tends to assume an equilibrium value for those conditions. This is a point of some industrial importance, as it indicates that the use of a grey cast iron of high initial combined carbon content is not the correct method to adopt to prevent or prolong the time in which the decomposition of the carbide takes place.

The influence of the various additional elements manganese, vanadium, nickel, chromium and tungsten on the decomposition of the combined carbon at these low temperatures has been investigated by Donaldson. As would be expected, the elements manganese, chromium and tungsten retard very considerably the decomposition of the carbide, whilst the elements nickel and vanadium assist the decomposition.

The Microstructure of Heat-treated Cast Iron.

An examination of the microstructure of low-temperature heat-treated cast irons confirms the analytical results regarding the decomposition of

FIG. 4.—GREY CAST IRON, HEAT TREATED × 50 DIAS.

the combined carbon. An interesting practical example is recorded in Figs. 1 and 2, taken from the head and gudgeon pin boss of a cracked automobile engine piston (water-cooled engine). Fig. 1, taken from the piston head, which has been exposed to the temperature conditions, clearly shows the substitution of ferrite for the pearlite present in the sample from the gudgeon pin boss away from the action of the heat. The chemical composition of this material was as follows:—C.C., 0.50; Gr, 2.78; Tot C, 3.30; Si, 2.10; Mn, 0.68; S, 0.08, and P, 1.25 per cent.

This example also clearly shows the increase in size of the graphite plates. This is a characteristic feature of heat treatment at high temperatures above the pearlite change point, and is in a large measure responsible for the reduction in strength properties observed in cast iron heat-treated in such a manner. Exactly what happens to the graphite deposited on the decomposition of the carbide after the low-temperature annealing treatment has not been definitely followed. In all probability this is principally deposited alongside the existing graphite plates. It is not observed to be deposited *in situ* in the place previously occupied by the pearlite carbide.

The development of the dendritic structure is very marked in samples heat-treated at higher temperatures, particularly in low-phosphorus irons. This has been shown by the writer,[5] and also the formation of the characteristic "bead-like" pearlite as shown in Figs. 3, 4 and 5. The lamellar structure of the pearlite in the normal specimen is shown in Fig. 5. The marked swelling of the graphite plates has already been referred to. This has been repeatedly shown by various investigators, notably Hatfield and Carpenter. This is characteristic of many cast irons heat-treated at various temperatures.

Influence of Heat Treatment on the Strength Properties.

In considering the influence of heat treatment on the strength properties, a sharp distinction must be drawn between those experiments in which

FIG. 5.—AS FIG. 4 × 250 DIAS.

the strength is determined at the particular temperature of heat treatment and those in which the determination is carried out at normal temperatures after having been subjected to heat treatment at a particular temperature for a period of time. Probably the earliest investigations into the strength of cast iron at various temperatures are those of Fairbairn.[6] Fairbairn found a marked reduction in the breaking load at temperatures of "Red by day" and "Red by dark." Up to temperatures of 320 deg. C. very little change was noticed in the breaking strength, and in some cases a marked increase in strength was recorded. The analysis of the samples used was not determined. The samples were prepared, however, from Coed Talon hot and cold blast irons respectively.

The strength of cast iron at various temperatures has been investigated recently by Meyer,[7] Schuz,[8] Mellanby,[9] Andrews[10] and Donaldson.[11] The exhaustive experiments of Donaldson show very clearly the falling off in strength at various temperatures and the influence of various additional elements on this phenomenon. In an ordinary cylinder iron in the as cast condition the

[5] J.I.S.I., 1917, No. 2.
[6] Iron, London, 1865.
[7] Meyer, Stahl und Eisen, Vol. XXVI, pp. 1270-71.
[8] Schuz, Stahl und Eisen, Vol. XLII, p. 1484.
[9] Mellanby, F.T.J., Vol. 30, p. 475.
[10] Andrews, J.I.S.I.
[11] Donaldson, I.B.F.F, 1921 and 1925.

tensile strength falls off rapidly as the temperature is increased after which a further rise in strength is noted up to a temperature of about 400 deg. C. Beyond this temperature there is a steady rapid falling off in tensile strength with increasing temperature. The curves platted showing the relationship between tensile strength and increasing temperature pass through a minimum at a temperature of 300 deg. C. in the cylinder iron used by Donaldson. This minimum is present in the curves of all the irons containing chromium, nickel, tungsten, manganese and vanadium investigated by Donaldson. The depression in the curves varies in magnitude and also in temperature in the various specimens examined. For example, the depression is hardly apparent in an iron containing chromium and in an iron containing both chromium and nickel it occurs at a temperature but slightly above 100 deg. C.

Similar depressions in the strength-temperature curves have been found by other investigators, *e.g.*, Rolfe.[12] Donaldson shows clearly that this depression is absent in the same irons tested at these various temperatures after having been subjected to a preliminary heat-treatment period before testing. He also shows that at the same temperature the strength values of the heat-treated irons are consistently lower than those of the normal irons. This reduction in strength value appears to vary with the duration of the preliminary heat treatment. This would appear to suggest that the falling off in strength to a minimum value in the " as cast " bars is in some way connected with the deposition of free carbon as a result of the decomposition of the pearlite.

At high temperatures in excess of the pearlite transformation temperature there is generally a serious falling off in strength. Hatfield has published figures in which a reduction of 50 per cent. of the strength was recorded after subjection of the bars to a temperature of 900 deg. C. for a few hours. This is generally ascribed to the expansion of the graphite plates which is invariably noted in such experiments. The extent to which this falling off in strength takes place varies in different cast iron, and in some cases the strength is actually increased. For example, in the case of permanent mould cast irons annealing or heat treating at a high temperature actually improves the tensile strength. The results obtained by Broughall[13] are given in Table III. In the sand cast bars a slight decrease in the ultimate strength values, both transverse

TABLE III.—*Composition of Sand Cast and Permanent Mould Cast Irons.*

Sample.	Tot C	CC.	Gr.	Si.	Mn.	S.	P.
	%	%	%	%	%	%	%
Sand cast ..	3.272	0.341	2.931	2.845	0.51	0.068	1.075
Sand cast, annealed ..	3.272	0.191	3.081	2.774	0.50	0.077	1.060
Perm. mould Cast	3.272	0.627	2.645	2.774	0.49	0.081	1.075
Perm. mould cast, annealed	3.300	0.110	3.190	2.774	0.52	0.071	1.102

TABLE IV.—*Strength Values of Cast Irons in Table III.*

Sample.	Transverse.		Tensile.	Compression.	Brinell.
	Cwts.	Ins.	Tons per sq. in.	Tons per sq. in.	
S.C. ..	23.675	0.14	11.30	50.12	170
S.C.A...	24	0.14	10.96	47.1	149
P.M.C.	27.125	0.10	15.22	70.78	269
P.M.C.A.	34.5	0.15	17.40	71.44	217

and tensile, is obtained, whereas in permanent-mould cast material a substantial increase in these values is recorded.

The exact reason for this variation in the behaviour of cast iron has not been satisfactorily explained. Some light is thrown on this in the later section dealing with volume changes. It is sufficient to point out at this stage that the common assertion that all annealing treatments to which cast iron is subjected are unsafe is not strictly true. Under certain conditions cast iron can be heat treated with perfect safety.

[12] Discussion on Hatfield's Paper, Royal Aero. Society.
[13] J.I.B.F., 1918-19.

Low Temperature Heat Treatment.

Certain automobile castings, such as cylinder sleeves and piston rings, are frequently subjected to a heat treatment at temperatures up to about 550 to 600 deg. C. for a short period. The object of this treatment is to eliminate the distortion troubles experienced during the initial heating up in the engine in the former case and to eliminate the permanent set in the latter case. These two features are probably closely related. It is well known that cast iron shows a certain amount of permanent deformation or set which commences at very low load values and increases with increasing load. The extent of this permanent set is always less on loading a specimen which has been previously strained, a fact which is probably due to the readjustment of the internal stresses in the casting. The effect of this low temperature heat treatment is of a similar nature, in that by eliminating the internal stress the subsequent permanent deformation under load conditions becomes more regular and less in magnitude and the liability to distortion under subsequent heat conditions is eliminated.

The influence of low-temperature heat treatment on the impact and other properties of cast iron is illustrated in the diagram Fig. 6, due to Rolfe.

Volume Changes and Growth.

The volume changes which take place in cast iron and its ultimate disintegration when subjected to prolonged high-temperature conditions and more particularly continued heating and cooling was first seriously investigated by Outerbridge.[14] The exhaustive investigations of Rugan

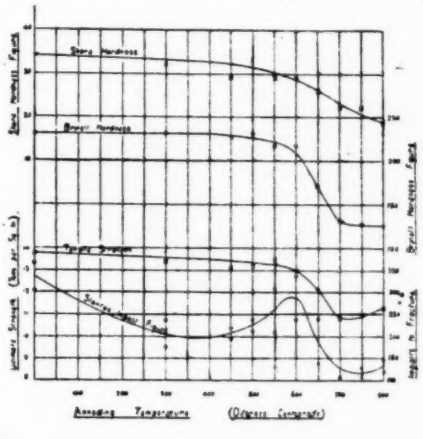


FIG. 6.—INFLUENCE OF ANNEALING ON THE PROPERTIES OF CAST IRON.

and Carpenter[15] have shown in great detail the mechanism of the permanent increase in volume which takes place in cast iron subjected to repeated heating and cooling. Whilst these investigators were fully aware of the fact that permanent volume changes took place when cast iron was subjected to lower temperatures, they considered that the type of volume changes or growth which they investigated commenced at a temperature of about 650 deg. C. This type of growth reached a maximum at about 750 deg. C. and at higher temperatures up to 900 deg. C. very little further expansion was noted.

The observations of Carpenter and Rugan are briefly summarised here. They observed that growth was confined to grey irons, and white irons showed no growth until free carbon was deposited in them as a result of the heat treatment. The extent of this growth was far in excess of the volume change which might be expected as a result of the precipitation of free carbon. This has been shown by Dr. Hatfield to be about 3 per cent. in those irons in which total precipitation of the temper carbon has taken place. In fact, increases in volume of the order of 63 per cent. were experienced by Carpenter and Rugan.

In their experiments on a series of bars containing from 3.4 to 3.98 per cent. total carbon, and 1 to 6 per cent. silicon, it was broadly shown

[14] J. Franklin, Instit., January, 1904.
[15] J.I.S.I., 1909 and 1910.

that the extent of the growth was roughly proportional to the silicon content. This growth was accompanied by an increase in weight which was shown to result from three causes:—

(1) A partial oxidation of the carbon which diminished with the increase in silicon and became nil at 6 per cent. silicon; (2) a probably complete oxidation of the silicon, originally present as the silicide of iron, to iron oxide and silica; and (3) a partial oxidation of the iron uncombined with silicon.

From these experiments Carpenter and Rugan concluded that the growth at temperatures above 650 deg. C. is primarily due to the internal oxidation of the constituents, chiefly the silicon, as a result of the penetration of the furnace gases into the interior of the cast iron by way of the graphite plates. Positive proof of this was found by these investigators in the experiment in which a specimen heated *in vacuo* showed no growth and heated in furnace gases showed an expansion in volume of 67 per cent.

In a further memoir on the same subject Carpenter draws the following additional conclusions:—(1) Phosphorus tends to diminish growth. If 0.3 per cent of this element is present growth is lessened by about 3 per cent. Higher percentages tend to diminish growth still more; (2) sulphur is never present in sufficient quantity to have more than a small influence on growth, which influence, however, is in the direction of retardation; and (3) manganese retards the rate of growth in all cases and diminishes the absolute amount of growth in the majority of cases.

Volume Changes at Low Temperatures.

It has long been known that at temperatures below 650 deg. C. repeated heating and cooling causes permanent volume changes in cast iron. This subject has been dealt with at length by Mellanby, Donaldson, and the writer. The extent of these volume changes is considerably modified by the composition of the iron. Elements like manganese and chromium retard the rate and extent of the volume changes; nickel and vanadium increase the rate and extent of these changes. Donaldson has shown a case of a grey iron containing chromium which actually shrinks after repeated heatings and coolings.

There is no doubt that these volume changes are largely brought about by the decomposition of the combined carbon, as explained above. That this is not the sole explanation is evident from the fact that the irons containing chromium actually shrunk, in spite of the precipitation of free carbon. So far as experiments show at present, however, there is no evidence of internal oxidation such as is met with in the growth phenomena.

The Influence of Thermal Expansion.

In the discussion of the researches of Rugan and Carpenter, Mr. Saniter discussed[16] the question as to why it was necessary to heat and cool the iron to make it increase so much in volume, and pointed out that this was in some way connected with the thermal expansion. Several Japanese investigators have studied these phenomena from this point of view.

The most important new experimental fact brought forward in these investigations is that grey cast iron when heated *in vacuo* undergoes permanent expansion.

This is contrary to the evidence of Carpenter and Rugan, but is undoubtedly well found. Two views have been advanced to explain this. The first view is that the permanent expansion is due to the liberation of the occluded gases and the permanent expansion is due to the pressure of the occluded gases. This view has been rightly discarded on the grounds that the porosity of the cast iron occasioned by the first heatings of the cast iron would allow such gases to escape at a low pressure. For this reason this view is unable to explain the continued growth with continued heating and cooling.

The further view advanced by Mr. Kikuta[17] is that the continued expansion of grey cast iron *in vacuo* during repeated heatings and coolings is due to the differential expansion of the various constituents which produce numerous fissures or cavities in the neighbourhood of the plates of graphite. In this view cast iron when heated in an oxidising atmosphere, owing to the different expansions of the various constituents, forms numerous cavities which allow of free entry of the oxidising gases. The oxidation of the constituents, which assists in the rapid permanent expansion of the cast iron, is subsequent to the initial permanent expansion resulting from the above cause.

Whilst the writer agrees that the thermal expansion is the primary cause in promoting permanent growth at all temperatures and that the chemical effects such as the precipitation of the carbon and the oxidation of certain of the constituents are to be regarded as secondary causes he is not in agreement with the detailed mechanism of the action as stated by the Japanese workers.

If we imagine a bar of cast iron of finite dimensions in the process of heating, and we imagine this bar to be built up of a series of layers of minute thickness, the outer layers are first to be heated up to the particular temperature. As we proceed inwards in the early stages of heating, each successive layer is at a lower temperature, and a temperature gradient exists from the outside layers to the centre for a period of time until temperature equilibrium is established and the bar is said to be evenly heated.

On cooling down, exactly the reverse of this state of affairs is the case, and until equilibrium is established there exists a temperature gradient from the centre of the bar to the outside layers.

The existence of these temperature gradients implies the existence of similar thermal expansion gradients across the section of the bar. These thermal expansion gradients are constantly reversed in direction according to whether the bar is being heated or cooled. The stresses set up across the section of the bar must be considerable and are constantly being reversed in direction, as in the case of the expansion gradients. If the material were steel, a ductile material, these stress gradients would produce distortion. In the case of a non-ductile material like cast iron the result of the stress gradient is a tendency to rupture the material, which eventually makes itself apparent in the form of open cracks extending into the bar.

The magnitude of the stress gradient will depend upon the thickness of the bar and the rate of heating of the bar, and it is of interest to note that Durand, in his investigations on growth, found that growth varied directly as the silicon content and inversely as the rate of heating. That is to say, the slower the rate of heating (the longer the stress gradient persists) the greater the growth, and *vice-versa*.

An interesting experiment has been made by the writer to demonstrate this. A cast-iron bar 1-in. diameter was sectioned into two pieces. A ¾-in. diameter hole was drilled through one piece and the other was used solid. The solid and hollow bars were heated and cooled in an electric muffle furnace side by side. The permanent expansion of the hollow bar in the same number of reheats was only 10 per cent. of the expansion of the solid bar. In a like manner it must have been common observation that thin stove grate castings, often not more than ⅛ in. in thickness, fail to grow in a manner which would be expected of them on purely chemical grounds. Such castings are generally of high silicon content, say, 2.75 to 3.00 per cent., and are used in such positions in household fire grates, etc., in which they would be expected to grow rapidly. On account of the thinness of such castings the rate of heating is so rapid as almost to preclude the existence of an expansion and stress gradient for anything but a very short period of time. Consequently their life is considerably prolonged.

The effect of the continued reversal of the expansion stress gradient is to cause the actual rupture of the material along the graphite plates. Once rupture has taken place in this manner the material is unable to return to its original form. Continued repetition of the heating and cooling causes further repetition of the permanent expansion in this manner. Once this has been started the oxidising gases can readily penetrate the material, and the oxidation of the various constituents assists the action.

[16] J.I.S.I., No. 2, 1909, page 129.
[17] See Levi, F.T.J.

The Production of Castings—with special reference to Iron Castings.*

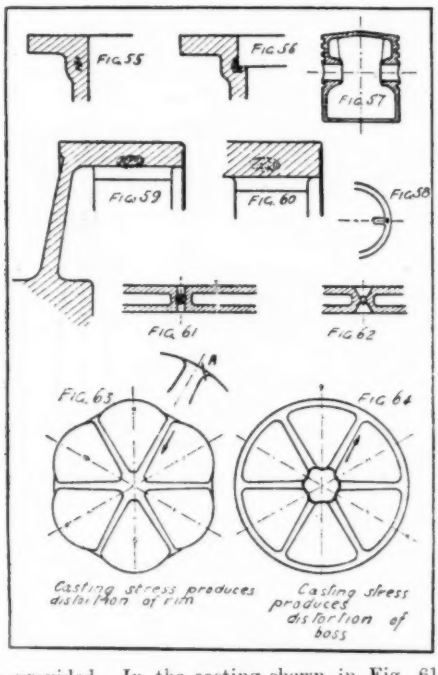
By Robert Lehmann.

(*Continued from page* 38.)

Piping and Cracks.

To obtain the greatest possible safety, as little as possible should be allowed for machining. The solid casting of the stuffing-box recess (Figs. 55 and 56) for a hydraulic cylinder lead to considerable piping and wastage. The same applies to many piston castings. The grooves for the piston rings are turned; at the junction points of the ribs small pipes are encountered (Figs. 57, 58), which causes pistons for high pressures to be rejected. The matter is still worse in the case of castings in which the parts are machined on both sides or are also milled (inner rim for gear with oil lubrication, Fig. 59). In milling the teeth, pipes are found unless at the outset the foundry has provided for perfect density of structure by means of risers and special composition. The piping becomes still worse if the toothed wheels are oil lubricated and the rim has therefore to be sealed externally. Owing to the centrifugal forces operating from within, the oil penetrates the rim outwardly. To strengthen the wall would, in this case, be no remedy at all, and would even increase the leakiness (Fig. 60).

If at all possible the wall thickness should be restricted, and where practicable openings should



be provided. In the casting shown in Fig. 61 a pipe was encountered in drilling a hole, and the casting became a waster. On being executed according to Fig. 62, with a partial opening, the piping was remedied.

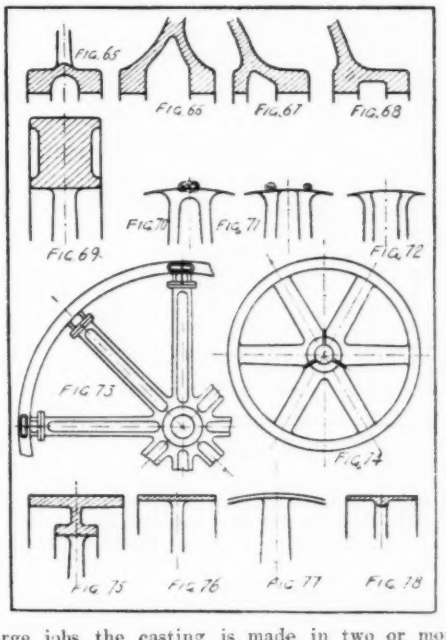
It is apparent from the foregoing examples that every point of junction may occasion piping; for this reason as few points of connection as possible should be made. Ribbed castings should be avoided as far as possible, and hollow castings should preferably be employed instead.

The conditions are still more difficult in castings where two parts of large mass, such as the boss and rim of a pulley, are connected by several arms or a solid centre. The arms cool more quickly, as they contain less material in proportion to the rim; they are already cold, while rim or boss is still hot, possible even molten, and may still draw. If the rim were elastic it would, after casting, take the form shown in exaggerated outline in Fig. 63. As the rim after cooling is rigid and does not conform to the change of form, stresses occur in the casting itself. If the cross section of the arms is too small so that they are not strong enough for these stresses, then cracks are caused (Fig. 79).

The solid rim acts from the outside in the same way as the solid boss acts from within. With a perfectly rigid rim and an elastic boss, Fig. 63, would alter as in Fig. 64. The forces at work would simply break a weak boss, and very often it is found in the fettling shop that pulleys to be split part at the dividing point. Here, again, the arm must be strong enough to stand the stresses arising.

If the principle of gradual transition, uniform wall thickness and the avoidance of accumulations of material is observed, the formation of pipes is prevented, and stresses are diminished (Figs. 65-67). Fig. 68 shows a faulty construction; notwithstanding the recess provided in the boss, piping occurs at the points of junction; the hot boss draws and causes special stresses in the arms.

The heavy fly-wheel rim shown in Fig. 69 will turn out very unsatisfactorily. Boss and arms must here be heavily dimensioned in proportion. Piping is unavoidable, whether the connection of the arms is according to Figs. 70, 71 or 72. The greatest safety is offered by Fig. 72. If it is a question of wheels of small diameter, these are cast with a divided boss to obviate stresses; the boss is held together with shrunk rings (Fig. 74). With



large jobs the casting is made in two or more pieces, or the rim is cast separately from the arms (Fig. 73).

The wheels, according to Fig. 75, are better structurally. Here the distribution of material can be made more uniform, and the connection of the arms is essentially better. With a small rim the arm must be well dimensioned and must also show a good rise. If the correct form of boss is also selected, as in Fig. 65, no difficulties will arise. It is the business of the designer to get the correct distribution of material between the individual members, if necessary by experiment.

In wheels, pulleys, etc., the points of junction of the arms with the rim are subjected to bending stresses by the centrifugal forces which arise. In addition to these stresses, there is at A—as is very clearly seen in Fig. 63—the stress due to the casting tension. The result is that in most pulleys cracks appear at this point. Points of junction without rounding or with too little rounding are certain to break (Fig. 77). For this reason the rims are frequently found with an inserted ring

(Fig. 78). Figs. 79 and 80 show unsatisfactory examples: Fig. 79 a weak arm, strong boss and rim, and Fig. 80 a strong arm, weak boss and rim.

The usual form of the arms for belt and rope pulleys is an ellipse, and for toothed wheels the + or the H-section. With the H-section exceptionally great accumulations arise at the boss, for which reason the bracket, as shown in Fig. 81, is to be recommended.

Even a solid centre gives no security against cracks if the boss is not dimensioned in the correct proportion (Figs. 82, 83). Preferably the centre is given a sloping or convex form, as stresses may thereby be compensated.

The foundry must naturally take care that the correct iron at the proper casting temperature is used for each particular job (large or small wall thickness).

It is not, however, only in pulleys with arms and solid centres that cracks may appear, but also in flat plates, bearing shields, etc., when there are accumulations of material (Figs. 84, 85) or the parts of the casting (cylinder covers, steam chest covers, etc.) are subjected to heat. (For fracture in steam chest covers see Bach's "Maschinenelemente.")

The cracks previously mentioned also arise after the casting has left the foundry, on removal,

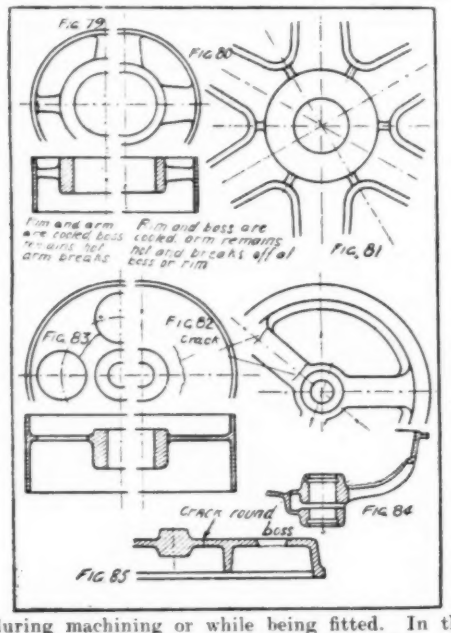


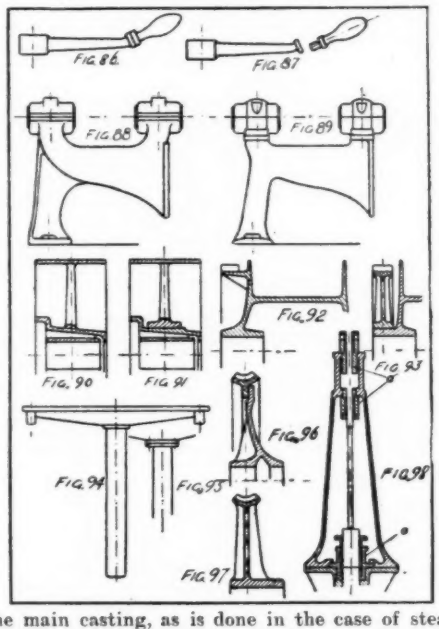
FIG. 79.
FIG. 80.
Rim and arm are cooled, boss and arm against hot arm breaks
Rim and boss are cooled, arm remains hot and breaks off at boss or rim
FIG. 81.
FIG. 82.
crack
FIG. 83.
FIG. 84.
crack round boss
FIG. 85.

during machining or while being fitted. In the latter case, however, a very careful test is necessary; for any expert will always maintain, when a fitting fracture occurs, that it is due to stresses. In wheels the designer should take in hand first the most solid boss, which is the principal cause of the stresses. At the junction points of boss with arm or solid centre the least admissible wall thickness should be selected. This can be done without further trouble by correctly placing the openings. Solid centres, covers and similar parts should also be given a shape which permits of stress compensation.

Frequently difficulties also arise owing to faulty composition of the metal. For a time all goes well, and then all at once wasters, owing to cracks, etc., occur with every casting. Simply to say "strengthen" is then not sufficient; the foundry manager must investigate and see whether the fault does not lie with himself. If this is not the case, he must consult with the designer as to how the defect can be overcome. The defect must be eliminated where it arises, and not by strengthening, which merely saves the one casting but allows the original defect to be repeated.

Economic Division of the Casting—Mass Production.

In working out the design it is necessary to examine to what extent the casting can be produced advantageously in one or several parts in the light of workshop, foundry or economic considerations. The ordinary cover in Fig. 42 has already shown the advantages which may be secured by so doing. In regard to the division of the lever in Figs. 86, 87 the question of cleaning would be the deciding factor. The handle loses its shape in grinding; the fitting shop has much work to do in giving it a good appearance. On the other hand, the polished handle, as a standard part, is not very much more expensive, but gives the casting a much better appearance. For the bearing shown in Fig. 88 the construction according to Fig. 89 would be preferable on account of workshop, foundry and economic advantages. The standard shown in Fig. 89 is simpler for workshop and foundry. The bearings supplied by a special foundry can be made much more accurately, and have therefore a considerable advantage economically. The same applies to the casting shown in Figs. 90, 91. Moreover, that in Fig. 90 causes difficulties owing to the large boss. For the castings shown in Figs. 92, 94 the constructions according to Figs. 93, 95 would be preferred from workshop and foundry considerations. The worm rim of Figs. 96, 97 is of bronze. Owing to the high cost of material the execution according to Fig. 96 would be preferable to that shown in Fig. 97. The standard in Fig. 98 is given replaceable parts at the points *a* where wear occurs. In the same way those parts at which in all probability defects arise would be separated from



the main casting, as is done in the case of steam cylinders. If there is no possibility of separation then the design is left alone. The foundry manager must use his ingenuity—for example, by inserting chills, or quenching artificially. The designer must, however, expect defects actually to occur, and must allow for them in advance in his calculations.

The further advantages of division are convenient storage and the mass production of articles, and at the same time the economical manufacture of parts.

If there is mass production the foundry occupies the same position as the engineering workshop doing repetition work. Special plant must be obtained; the details of the casting may have to be completely altered to be suitable for mass production, and very often the form of the main body may also have to be modified. By stripping plates and other moulding machine appliances the same advantages are obtained as in the engineering workshop by machine tools.

With machine-moulded castings, however, perfectly clean, well-fitting parts with little fin can be obtained, together with a large output at a low price. The requisite plant will only pay, however, when the number of castings produced is large.

Not every designer can occupy himself with these problems. This is a province which demands special technical knowledge in regard to moulding machines. The firms concerned, as well as the foundry manager, would have to be consulted.

Some Large Marine Valves.—Part III.

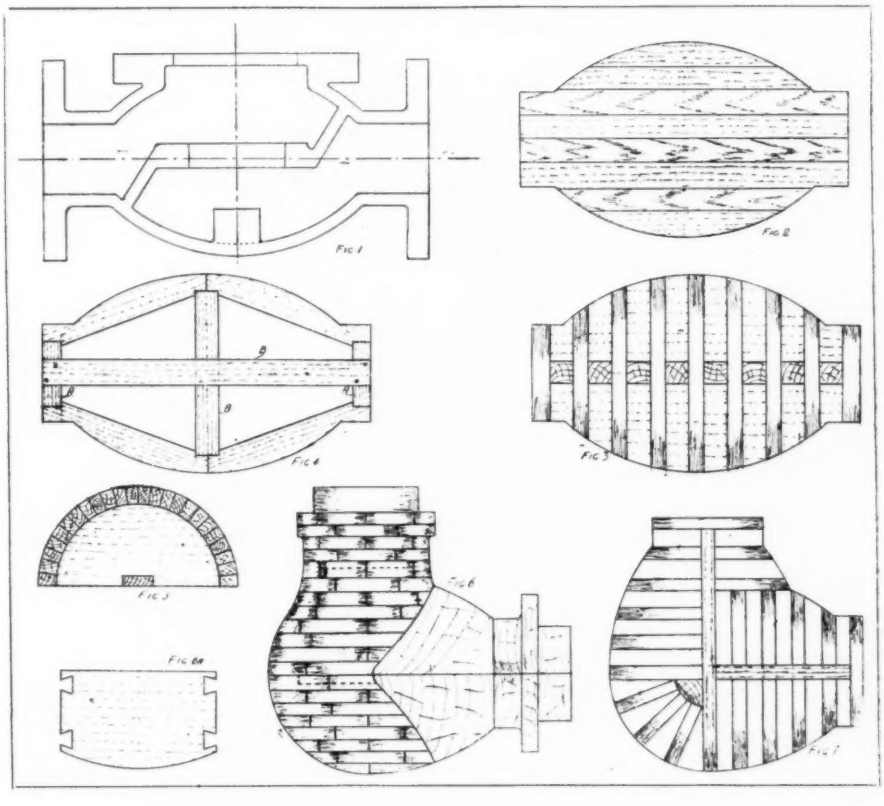
By Ben Shaw and James Edgar.

GLOBE VALVES.

Globe valves of one kind or another are made in many engineering shops besides marine shops, but those of large size are more common in marine shops than in other engineering shops. We say globe valves "of one kind or another" because the general term "globe valve" does not convey any meaning as to the purpose for which the valve is going to be used, nor is it descriptive of its characteristics. We cannot cover all kinds of globe valves in this article, but only one or two representative types. Globe valves may be stop valves or screw down valves.

A globe valve may be defined as an elliptical or oval body from each end of which there is an outlet and an inlet valve respectively. When the branches are on the same straight centre line the valve is described, in workshop parlance, as a "through" valve, and when they are at 90 deg. to each other the valve is termed a "right angle" valve. When the branches are inclined to each other at other than a right angle the valve is simply called an "angle" valve. In internal design there is considerable variation, sometimes determined by the work for which the valve is going to be used, and sometimes because of the ideas and experience of the designer. It would be an exaggeration to say that these are the most difficult valves the patternmaker and moulder have to make, but it is simple truth that, as a class, they present at least as much scope for ingenuity as any other class of valves. This is evident from the fact that, in different districts, and in different shops in the same district, the methods of making them vary. For instance, with small valves the core is frequently made in two or more boxes, and where one box is used, two cores are sometimes made and connected by a print on the valve seat. This variation of practice, which, of course, obtains more or less in all classes of work, leads to much confusion, in the minds of young craftsmen especially, as to which are the better methods.

Fig. 1 represents a "through" valve. The design is quite orthodox. The rims which join the valve seat to the outer metal are sometimes straight and occasionally curved. This is not really a difficult pattern to make. When it is of medium size it may be made of solid timber and built of 1½-in. yellow pine jointed back-to-back. Fig. 2 represents a joint view of such a pattern. Sometimes very large valves are made in this way and each piece of timber is cut so that the pattern is really a hollow shell, but this is a bad constructional method. When a pattern is too large to be made solid it should be properly built either with segments or staves, according to which is the more suitable. It is not often that many valves are required at the same time, and, because of this, the skeleton method of construction is common. Fig. 3 is a plan of a skeleton pattern before the flanges or prints have been screwed on. The joint plate is shown solid. Between the section pieces, it will be observed, distance pieces are fitted which keep the whole construction very rigid.

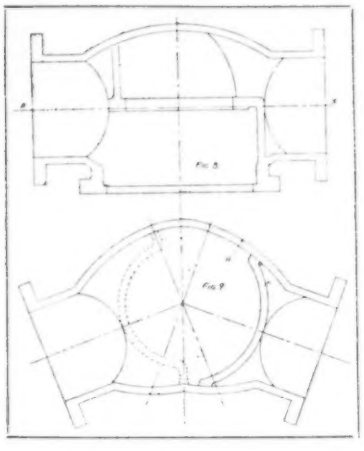


A method of construction which is equally suitable for solid or skeleton pattern is shown at Fig. 4, which shows a joint view. AAA are grounds which may be 2 to 2½ in. thick. B is a batten which is set into these grounds and binds them together. The diameter is made up of section pieces, as shown, which can be made from a template. When a solid pattern is made it will appear as Fig. 5 when built, and the "staves" can be quickly planed by the aid of a jig on the planing machine. This form of construction is very rigid, and the result is a pattern that will stand much usage.

With regard to the corebox for a large through

valve, this is very commonly made skeleton method, the section being built inside a rectangular framed box. It is generally not only more economical, but more convenient to make a half core-box, the top half of the core being strickled on this. The seat and ribs are the most difficult part of the corebox, and we shall consider them further on in this article.

When angle valves are what may be termed a



medium size, that is about 6 in., they are too small to be built hollow, and yet for reasons which we have explained in previous articles, they are too large to be made from solid timber in one thickness or two thicknesses jointed parallel with the pattern joint. The only alternative to ensure a reliable pattern and resultant accurate castings is the method of gluing thicknesses of timber at right angles to the joint, similar to Fig 2, but with valves over this size there are several methods equally good. Fig. 6 illustrates a good pattern so constructed that the branches can be turned round to form either a through valve or a right-angle valve, and, as both the main pattern body and branches are turned, they will fit equally well at any angle. It is, as the illustration shows, segmentally built. The segments need not be above 1½ in. wide and, as with all segmental work, the thinner they are, provided they are not less than ⅝-in. or so, the stronger is the pattern. It will be seen that the two joints are each formed by means of a spigot. While yellow pine will make a good pattern of this class, it is made much more durable if the joint segments and spigots are made of bay wood and also the top of the dome or sphere.

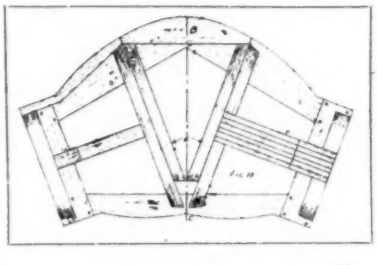
A cheaper pattern for a medium sized valve, such as would be suitable from which to make a few castings, is shown by Fig. 7. It is a skeleton pattern, in two halves preferably. It is a very simple example of the skeleton principle of construction. Two joint plates have first to be made, and it is much better, even if it is a bit more expensive, to half-lap the joint frame, but, if one or two castings only are wanted and these in a hurry, two widths of timber with temporary battens to hold them together, while the section pieces are being fastened, will answer the purpose. To get out the pattern very quickly, the two plates should be dowelled and then finished together, after which lines should be drawn for the section pieces, and the screw holes bored through both plates at one operation.

It is much the superior way to make the cover branch of solid timber and fit it over the skeleton body, because, while it could be made as part of the body, it is not a commendable practice to make either top or bottom branches other than solid.

It is obviously impracticable to make the largest sizes of angled valves of solid timber, and although the segmental method could be adopted for some types, even in the largest sizes there is the great difficulty of jointing timber for the branches in such a way that strength will be obtained. Other types of large valves do not lend themselves to segmental construction at all, and Figs. 8 and 9 represent a valve of this class. It can be truthfully said therefore that the segmental method is not suitable for very large valves. Nor is the skeleton method suitable for such valves because building the grounds would take much time and the necessary degree of rigidity would be difficult to obtain. The method which appears best to the writers for the construction of these large patterns is equally applicable for a solid as for a skeleton pattern, the only difference being that spaces would be left between the shape defining pieces, and there would thus be a considerable saving of time in fitting and jointing, as well as economy of timber.

Fig. 9 is a plan of Fig. 8 on the line AB. It is necessary, both on account of coring and also for convenience in constructing it, to joint the pattern on the line AB, Fig. 8, the cover flange being moulded down. The most convenient way of dealing with the flange is to screw on loose segments to draw into the mould. The joint frames ought to be not less than 1½ in. thick so that they will not bend or be easily warped out of shape. The shape of this pattern is such that two end portions for each half can be built and the distance between subsequently fitted in.

As no advantage is gained by building the pattern in sections, and then assembling the various parts, it is as well to screw the grounds to the joint plates, fit the distance piece between them, and screw on the section pieces which will be planed on a special table on the planing machine in the manner which has been described in a previous article. Screws are superior to nails for fastening the section pieces on the grounds. It makes a neater pattern if only every third or fourth piece is screwed to the grounds, those between being fastened to the previously fitted section piece. Building in the wedge spaces between the two ends is awkward, chiefly because the section pieces cannot all be finished from a template. The grounds A, Fig. 10, are shaped so that no fitting of the edges of the section pieces will be necessary. The elliptical shape ought to be drawn on one face, a jig made and the ground screwed to it when the edge can be truly sawn and sandpapered to shape. The jig need only be 2 in. thick, as this will give a sufficiently steady bearance on the machine table. If one ground is finished off, the other three are easily drawn from it by the "back to back" method, that is by placing one face against another, and marking round it with a scriber, the shape of the reverse ground is obtained. Although the section pieces have to be fitted separately they can all be planed together at the



machine. A section on the centre line BC, Fig. 10, is a diameter and it is a simple matter finding the taper on the section pieces. In building, it is well to begin with the top piece. If this is done, and a quarter circle template made of the diameter BC, each piece can be easily shaped as it is fitted to another, a template of the radius A, Fig. 9, being used. At the sharp end a solid block is better than thin pieces. The whole shape when built may be touched-up with a spokeshave and sandpapered.

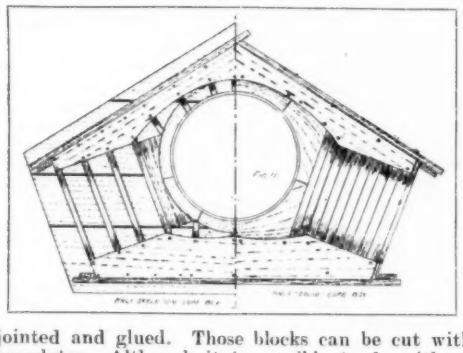
For the cover branch, the easiest and the best way is to build a segmental ring and bed it on the body, a fitting line being obtained by projecting points. Because of the short distance from the face of the flange to the centre of the chest the valve body will project above the flange but a hollow print constructed of a top plate on a double thickness segmental ring will cover it. The flange can be so divided with a key piece that it will draw into the branch. A very good way

of dealing with a flange like this, if the pattern is going to be much used, is to dovetail the flange segments to the body ring. The dovetails should be of baywood or other hard wood and need not be more than $\frac{5}{8}$-in. thick.

The branch flanges may be built in several thicknesses sufficiently wide to give a good bearance for prints, which should be about 3 or 4 in. thick. In order to get a centre on the face of the flanges a batten should be screwed across the face. There are usually ribs and a boss or two on a valve of this size, but they present no difficulty.

It is not practicable to make the core without at least a full half box with a wedge-shaped box sitting on it, the ends or branches being strickled. A good skeleton may be made, or a solid corebox, according to the foundry's requirements. We shall consider both types of box here. Fig. 11 is a plan showing a skeleton construction on one side and a solid construction on the other. In order to strickle the top half of the box it is advisable to make the cover branch core in the full box. The difficulty of sweeping up the round cover branch core on the top can be readily understood, and it would not be worth while strickling all that remained if a box was made for it. Thus, if the cover branch core is not made in the full half box a full box may as well be made. On the bottom, it is a convenience to set out the shape of the core-box on the joint and the necessary sizes for the enclosing frame are thus seen; $1\frac{1}{2}$-in. timber should be used for this frame and this is a suitable thickness for the entire box. The bottom plate is cut through and a thick ring of segments screwed on the underside to make the distance to the face of the print. This is better than making the bottom plate to the face as it saves unnecessary building inside the box and thus effects a considerable economy of timber. Inside a segmental ring is better than section pieces. There is no difficulty in drawing off and making the shape defining pieces for the branches or any other part of the box.

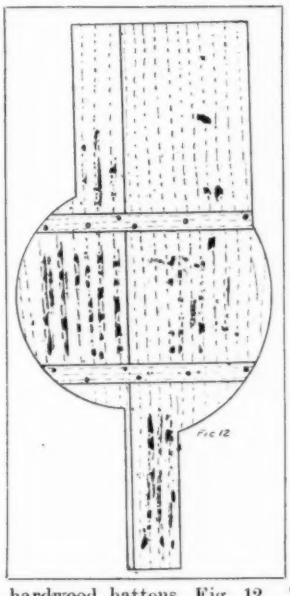
The branches for a solid box ought to be built, and as the branch half diameter is not nearly the depth of the box, a platform should be made which consists of a flat plate resting on two legs, and there is no need for shouldering the legs into the plate as the platform will be covered up when the box is finished, and thus cannot be knocked. The segmental ring should have a front plate screwed to it, and flush with the end of the platform. Instead of a segmental ring for the centre core, blocks should be made of timber conveniently



jointed and glued. Those blocks can be cut with templates. Although it is possible to do without joint plates in a solid box, they are an advantage. It is never wise to have the face of a core box in many separate joints if it can be avoided, because the coremaker cannot be expected to make a decent joint if the surface of the box is irregular, and when end-grain and side-grain are on the same face it does not remain long straight.

The top part of the core-box should not present much difficulty. Here, again, there must be an outer frame screwed to a bottom. The centre portion can be built in a fashion similar to the same portion of the pattern. Considerable parts of the branch cores have to be carried on this box, so that it will be a reasonable bearance on the bottom half-box.

A segment to form a runner for a strickle is screwed on the outsides of the top box. This serves the double purpose of a guide for the strickle and a support for a centrepiece to which the ribs which support the valve seat can be screwed. The ends of the box are shaped so that the strickle and the rib-support bear on them. The plate for the valve seat, because of its size, will probably be jointed of two widths; but whether it is in one or two pieces, it is good practice, in order to keep it from warping, to



inset two hardwood battens, Fig. 12. This plate can be dowelled on the box joint. The circular ribs will, of course, be made by the segmental or lagged methods.

With regard to large globe seats and ribs, the seat is usually made as a solid plate with a cored centre and the ribs whether they are straight, or circular, are made separately. The fitting shape can be marked and cut before the ribs are placed in the box by projecting points geometrically or by using a jig. It is sometimes advantageous to mark a fitting line geometrically, and still use a jig for fishing. For a through valve, the most effective jig consists of two semi-circular grounds screwed to a plate with a longitudinal template of the valve shape riding on them, the grounds representing the ends of the valve. When the ribs form a part of a cylinder or a core they may be built with thin segments or by means of narrow staves. When, on the other hand, they are straight and vertical from the joint of the box the valve core may be made in two halves, and the ribs dovetailed to the seat. Such a seat, with the dovetails cut to receive the ribs, is shown at Fig. 6A. The design of the ribs frequently settles the construction of the box. If the ribs are circular, it is generally advisable to make the seat on the same plane as the corebox joint, and the cover core is then cut through the bottom of the box. When the ribs are straight, however, the cover core is cut through the side of the box. In the case of an angle valve, of course, such as those already discussed, only one method is possible.

Catalogue Received.

Lining Bearings.—A really useful brochure has been sent to us by the Hoyt Metal Company of Great Britain, of Deodar Road, Putney, London, S.W. Whilst it obviously takes its own brand as an example, the information given is of general utility. There are 12 pages and 9 line drawings, and its scope will be indicated by a statement of the section captions, which are Hints on Lining Bearings—Turning—Heat—Pouring; Blowholes; Lining Large Bearings; Aviation Bearings; Suitable Outfits for Lining Small Numbers of Bearings; Jigs or Moulds; Preventing Leaks in Jigs; Machining; Causes of Hot Bearings; Oilways and Lubrication; Filling Petrol Engine Bearings. The catalogue is one of the most useful we have reviewed for a long time.

Losses Incurred in Melting Iron.

BY VALLISHE.

This article is inspired by " R. P.'s " foundry query as to what milling loss can be considered as normal. The loss of *iron* in the cupola may, as a general rule, be taken at about 2 or 3 per cent. The three chief causes determining this loss are as follows: (1) Insufficient fuel—a common cause. The air in the blast not to be all used up in the combustion of the fuel, part of it is left free to combine with the iron, the resulting oxides passing into the slag. (2) Too much air admitted, thus increasing the amount of iron that is oxidised. (3) Insufficient limestone to flux away the silica. Compensation is gained, however, in the fact that more of the iron will oxidise, thus forming iron oxide, which is a good substitute for this flux.

Oxidisation in the Cupola.

A considerable percentage of iron is lost through oxidisation in the cupola. The greater the surface exposed to the action of the blast the stronger its pressure. Again the thicker the scale (rust) or dirt on the iron the greater the loss from this cause. The following examples will give some idea as to the importance of this loss. Burnt iron (firebars, retorts, etc.) will show a loss ranging from 30 per cent. up to nothing at all but slag (jobbing foundries should take careful note of this). Stove castings, if clean, show a loss of nearly 20 per cent. Scrap-iron plate (2 to 3 in. thick) generally loses from 6 to 8 per cent. Chilled pig-iron, *i.e.*, sandless, shows only a small comparative loss of about 4½ per cent., whilst sand pig-iron (common pig), if cleaned, loses about 5 per cent. It is well known, and experience shows, that much better results are obtained if the fuel bed is low, combined with a mild blast. Care should, however, be taken in picking the iron from the cinder, or unnecessary wastage is entailed. More " shot-iron " comes down from a low-fuel bed than a high one. This is due to the fact that the latter will melt cleaner at the close of a heat, leaving less refuse sticking to the cupola sides. Iron is also lost in the slag, this loss being governed by the size of the slag-hole and the pressure of the blast.

Silicon Losses.

The loss in silicon during melting is an important factor, especially when a casting of given analysis is specified. Several tests have recently been made in order to determine the probable losses in silicon under ordinary conditions. Table I gives the results of a recent test, the results being fairly reliable, as compared with other similar tests.

TABLE I.

Per cent. of silicon in original mixture.	Decrease per cent. due to loss in cupola.
1.00	Almost negligible
1.20	0.041
1.30	0.060
1.40	0.083
1.60	0.131
1.75	0.190
1.90	0.230
2.00	0.250
2.20	0.270
2.30	0.274
2.40	0.277
2.50	0.280
2.75	0.287
2.90	0.290
3.00	0.300
3.25	0.320
Above 3.25	0.330

Manganese Loss.

Tests have also been made to ascertain the loss in manganese during melting. Table II gives results, assuming, of course, there are ordinary percentages of sulphur in the mixture. If, however, sulphur is present in large amounts, the losses will be considerably greater. As manganese readily combines with sulphur a slag is formed containing manganese sulphide. In some cases of extreme nature, it has been known for the manganese to be nearly 45 per cent., due to large quantities of sulphur being present.

The Total Loss in the Cupola.

The total percentage of metal lost must always depend on the nature of charges and the general conditions, and is made up of (1) loss in the iron, as previously stated; (2) loss in manganese and silicon; (3) loss due to sand, rust and dirt entering along with the charge. Compensation, however, must be allowed for a small gain in sulphur, and thus the total loss would be more explanatory if it was termed *net-loss*. Greater loss of iron is incurred from scrap than from pig, due to more sand and greater oxidisation taking

TABLE II.

Per cent. of manganese in original mixture.	Decrease per cent. due to loss in cupola.
0.4	Almost negligible
0.5	0.04
0.6	0.06
0.7	0.11
0.8	0.15
0.9	0.25
1.0	0.30
1.1	0.37
1.2	0.40
Above 1.2	0.43

place. The thinner the scrap, the greater the oxidisation, due to a greater surface area than an equal weight of pig-iron. From this it is easily understood that the total loss of material largely depends on the percentage of scrap in the charge. Roughly speaking, however, this total loss generally ranges from 4½ to 5½ per cent., but should not exceed 7 per cent. If a total loss of over 7 per cent. is found, investigations should be made, as there is something wrong somewhere. Assuming the amount of metal required at the tapping hole to be 30 tons, the charge should be (assuming a total loss of 5 per cent.) 31½ tons. A total loss below 4 per cent. is seldom found.

Loss from Charge to Finished Casting.

Assuming a foundry to have 1,000 tons of scrap, pig, etc., what weight of finished (dressed, but not machined) castings would be obtained? To base a certain definite percentage loss is, of course, impossible, as conditions in foundries vary greatly. Take all the losses that are entailed and divide them as follows:—(1) Total loss in cupola, as previously explained; (2) losses on the charging floors, due to unforseen causes; (3) loss due to emptying the cupola when all the casts are made. This loss is sometimes considerable if proper care is not taken in correctly estimating the amount of metal required for the day's cast. The metal left in the cupola, when poured into open trenches in the sand, is subject to much oxidisation, entailing unnecessary (up to a certain point) loss; (4) losses entailed in the dressing or fettling shop. Care should be taken in collecting all risers, etc., and dumping them on a convenient scrap heap. Much weight can be saved here if supervision is good; (5) loss of weight if a large percentage of bad castings are made. It may at first seem that items 2 to 5 are practically negligible, but if a foundry is to be run on sound, economical, business lines, they must be taken into account. Assuming the net cupola loss to be 5 per cent., an additional 2 per cent. should be added to cover the other items mentioned. Thus a number of charges totalling a weight of 1,000 tons would really produce $1,000-(\frac{7}{100}\times 1,000)=1,000-70=930$ tons. For jobbing foundries a 7 per cent. loss is a fair average percentage.

SPEAKING AT THE official opening of the new sports ground of the General Electric Company, Limited, comprising some 20 acres at Wembley, Sir Hugo Hirst, Bart., chairman of the company, said that he considered it good business for employers not only to study working conditions inside offices and shops, but to pay great attention to recreation and happier conditions of the workers outside office hours. He never asked himself whether the considerable capital, amounting to several hundred thousand pounds, which his company spent for that purpose, was invested in a paying proposition. He was quite satisfied it was a good thing for the company, for the staff and for the country, if the chance for enjoyment and rivalry in sport was given to people who work for a common object.

Visiting Industrial Centres Forms Part of Students' Curriculum.

As part of their training, the students at the Paris Foundry High School spend a portion of their vacation touring the foundries in a circumscribed locality. This year the North of France was chosen. Each student has to describe the noteworthy features in a report to his professor. Amongst the foundries visited was the Etablissement Wauthy, near Douai, which is noted for the excellent bell castings it turns out. In addition to the bronze foundry, a large grey iron foundry is in course of erection, it having been destroyed during the war. When finished it will be one of the most important foundries in Northern France. A fair amount of loam moulding is already carried out, ordinary building bricks being used as reinforcements. For the melting of the bronze, tilting furnaces of 10 tons capacity have been introduced. At the Serielle-Mauberge foundry castings up to 50 tons are regularly turned out, the monthly production well exceeding 1,200 tons. The steel works at Feignes specialises in railway castings, whilst the Miroux Foundry at Ferrière la Grande is solely devoted to non-ferrous, using both pit-fired and Morgan tilting furnaces as melting units.

The steel works at the Forges et Ateliers Electriques de Jeumont is provided with two 6-ton open-hearth furnaces and two 30-cwt. converters for making their castings, the majority of which are machine moulded by jar-ramming or pressing. In addition, there is a malleable iron foundry devoted to the manufacture of bicycle parts. Aluminium bronze castings are regularly and successfully produced.

Another modern foundry which was included in the tour was the Etablissements Sculfort, Feckedey and Vautier. A modern German automatic sand conveyor was the outstanding feature commented upon by the majority of the students.

This tour brought to the notice of the students the large variety of local sands used in the North of France, and the green sand castings made from them have a better finish than when made from the sands coming from the Paris region.

We believe the idea of students' tours to be thoroughly sound, and one that could be usefully copied in Great Britain.

Foundry Query.

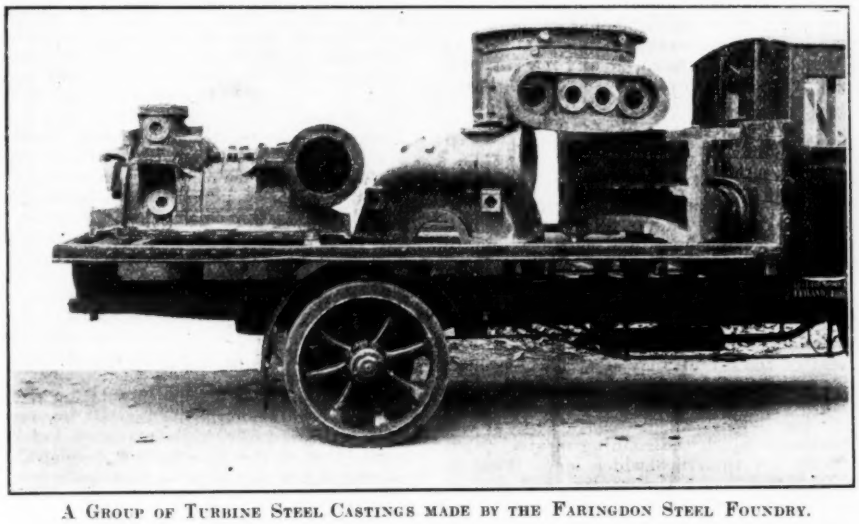
I shall be glad if any of your readers could give me some data showing what is the usual percentage melting loss in steel produced with a cupola and a Tropenas converter.

Assuming that 1,000 tons of metal are charged into the cupola, what is the usual weight of liquid steel actually obtained in the ladle?—G. H. B.

[The cupola losses are dealt with elsewhere in this issue.—ED.]

Automobile Concern Makes Steel Castings.

The photograph reproduced below of some heavy steel turbine castings were prepared by the Faringdon Steel Foundry of Leyland Motors, Limited, to the order of Messrs. Yarrow & Company, of Glasgow. These castings were photographed on their departure from the foundry for Glasgow.



A GROUP OF TURBINE STEEL CASTINGS MADE BY THE FARINGDON STEEL FOUNDRY.

Whilst being better known as manufacturers of lorries and the Trojan motor car, the Leyland concern have built up a considerable reputation as steel castings manufacturers.

A.F.A. Syracuse Convention Papers.

The following Papers are expected to be submitted to the annual Convention of the American Foundrymen's Association, which is to be held at Syracuse from October 5 to 9:—

"Melting Cast Iron in the Electric Furnace," by George E. Lamb, Lamb Machinery Company, Hoquiam, Wash.

"Grey Iron Foundry Problems," by J. H. Hopp, Hopp-Patterson Company, Chicago.

"Mechanical and Physical Properties of Grey Cast Iron and Semi-steel," by O. W. Potter, University of Minnesota, Minneapolis, Minn.

"Nickel in Cast Iron," by Dr. Paul D. Mercia, International Nickel Company, Bayonne, N.J.

"Oxygen in Cast Iron," by a representative of the U.S. Bureau of Standards, Metallurgical Division, Washington, D.C.

"Relations between Engineering Properties and the Constitution of Cast Iron," by J. W. Bolton, Niles Tool Works, Hamilton, Ohio.

"Influence of Phosphorus on the Total Carbon Contents of Grey Iron," by James T. MacKenzie, American Cast-Iron Pipe Company, Birmingham, Ala

"Superheating Iron in the Cupola," by S. J. Felton, Ohio Mechanics' Institute, Cincinnati, Ohio.

"Dilatometric Study of Graphitisation," by Albert Portevin and Pierre Chevenard, annual exchange Paper of the Association Technique de Fonderie de France.

"Cupola Investigations," by John Grennan, University of Michigan, Ann Arbor, Mich.

"Core Binders," by H. L. Campbell, University of Michigan, Ann Arbor, Mich.

MR. W. RAWLINSON, the Manchester local director of Messrs. Jackman & Company, Limited, has changed his private address from Woodston, Hilton Lane, Little Hulton, to Fairhaven, Ellesmere Park, Eccles.

Physical Chemistry in Steel-Making.*

By Sir R. A. Hadfield, Bt., D.Met., F.R.S.

Physical chemistry is the fundamental science of steel-making. Most of the classical studies in physical chemistry have, of necessity, been confined to a field of activity in which the severely high temperature conditions of steel-making do not obtain. On the other hand the numerous factors, sociological as well as material, which must influence any industrial operation have helped to confine the progressive developments of the art of melting and refining ferrous metals mainly to methods which may be termed, at any rate to some extent, empirical. However, it should be recognised that the great developments of Bessemer, Siemens, Gilchrist, and Thomas were based on a reasoned structure of chemical and physical science, and not mere chance discoveries.

During the last two decades there has arisen what may almost be described as a new age in metallurgy, that of the alloy steel, and its rapid strides have been no doubt in a measure due to many series of systematic researches and the better understanding of a domain of science that is governed by the laws of physical chemistry. This new field of progress is so important because of the remarkable properties obtained, and by the development of the use of alloy steels the engineer has been provided with material permitting progress as to design and utility, hitherto undreamt of.

The furnace in which the refining of steel takes place is really an appliance which lends itself to scientific operation, since the weights and composition of the materials used and the concentration of essential constituents of the bath and slag are capable of fairly accurate measurement, and the thermal conditions are controllable within limits. The basic reactions of steel-manufacture depend upon some chemical reaction of oxidation, reduction or some reversible displacement in a somewhat viscous liquid phase, and the resulting changes are largely influenced by temperature conditions. The quantitative course of many of the reactions are not known in any exact terms, though means of judging approximately the course of the various operations, aided by chemical analysis, are known to those skilled in the art.

There is a further factor in steel-manufacture influencing the process much beyond the order of complexity found in those reactions usually studied in the classical researches, and that is the physical condition of the molten steel. The point is perhaps well illustrated by reference to the specific purifying action of manganese, apart from its deoxidising action, in the manufacture of high-grade steels in the open-hearth furnace. It cannot be denied that physical factors are of supreme importance in molten steel. Such are primarily the viscosity or fluidity of the slag and steel, and surface-tension effects which determine the important question of clarification from non-metallic inclusions.

Passing allusion may be made to those allied branches of steel-making—the fuel and refractory materials used. The basic science of these is again physical chemistry. The study of the equilibria in gaseous reactions has not only enabled gas-producer operation to be placed on a scientific basis, but has also pointed out directions in which a greater availability may be made of the hitherto waste gases of iron and steel works, in particular to the use of blast-furnace and coke-oven gas, both in the open-hearth furnace and the gas engine. Recently it has been shown that with a moderate injection of steam a mixture of 85 per cent. of producer gas and 15 per cent. of coke-oven gas may be used in a regenerative furnace, whereas the regeneration of coke-oven gas alone is attended with serious loss of combustible, due to cracking of hydrocarbons in the chequer chambers.

The future development of all classes of steel-making processes must depend in some measure upon refractory-material research, since the present temperature limits are governed by the properties of the materials used in the furnace structure. The same limits must also influence the possible use of oxygen, which has been shown, on purely theoretical grounds, to have certain advantages. These subjects alone are fields representing great possibilities in the future.

Cognate studies which are of some interest to the steel-maker are those fundamental inquiries which are receiving increasing attention at the present time, the constitution of the binary, ternary and quaternary alloy systems. This of course opens up a field of future discoveries in which systematic study of the simpler combinations may be a prelude to the possible production of new types of steel. Work of this kind has been undertaken by the Ferrous Alloys Research Committee of the Institution of Mechanical Engineers, amongst the projected studies being that of the constitution and physical properties of the binary alloys of iron in the absence of carbon. With the aid of Dr. W. Rosenhain, a beginning has been made at the National Physical Laboratory with the iron-oxygen system. The effect of oxygen in steel still remains one of the most important problems facing the metallurgist. One of the chief difficulties in carrying out these high-temperature researches on materials of special purity is the construction of a furnace of suitable type and materials of adequate refractoriness to prevent contamination of the melt with impurities from the furnace linings. These studies of the influence of oxygen also open up the question of the future possible use of the vacuum furnace.

Some progress towards the solution of this problem has been made during the last few years by the appearance of the high-frequency induction furnace, though the type so far developed does not permit of refining at least in a deliberate and controlled way. It enables, however, the use of vacuum, under which conditions a certain degree of refining appears to take place. So far has the application of the system been carried, that already fairly considerable commercial use of the high-frequency induction furnace has been made in the melting of non-ferrous metals and in particular high-permeability alloys for use in marine cables. The chief advantage of such furnaces lies in the fact that, provided the charge is of an electrically-conducting nature, which is of course the case with metals, the heat is generated actually in the material to be melted, which constitutes the secondary of the electrical system, a watercooled copper coil as inductor being carried round the crucible in which the melting is done. The principle of the method of heating would therefore appear to be ideal. It also permits of conservation of heat in the crucible by suitable lagging. Non-conductive materials can be dealt with by the use of conducting crucibles, in which case the heat is generated in the crucibles and so transmitted to the charge.

Finally, whilst the character of individual researches must vary widely with the class of operation, the following are a few of the problems, which in addition to those mentioned above are of sufficiently general a character to apply to all, and are of importance to the science of steel-making :—

(*a*) The study of the equilibria of slag reactions, which are the key to the reactions in the steel.

(*b*) The mechanism of the origin of slag inclusions in steel, and means for their elimination.

(*c*) The reactions between molten metals and the refractory materials constituting the hearths and banks of furnaces, and the conditions of penetration of combined and "adsorbed" oxides.

(*d*) The study of the physical properties of slag at high temperatures, viscosity, fluidity, surface tension.

(*e*) A study of the mode of the cooling of ingots, which would throw light on the problem of segregation, and the physical properties of the segregates.

Further development of the work on the equilibria of the oxides, SiO_2,CaO,MgO,Al_2O_3, and the reducible oxides, FeO,MnO, undertaken originally by the Geophysical Laboratory of Washington for geological purposes, would be of value in furthering the study of the subjects referred to in paragraphs (*a*), (*b*), (*c*), above.

The reduction of sulphur in acid practice, direct reduction of ores, and the use of oxygen, are problems in which any ultimate solution must depend largely on the development and application of the fundamentals of physical chemistry.

* A Paper read before a joint meeting of the Faraday Society and the Iron and Steel Institute.

German Foundrymen's Association.

From June 18 to 22 the German Foundrymen's Association held its annual general meeting in Munich, there being a large attendance of members. Many guests of honour were also present, including His Excellency Oscar von Miller, the founder of the Munich Museum, as also representatives of Government bodies, technical high schools and mining colleges, while nearly all the leading technical associations had sent their representatives.

On the first morning, after an address of welcome, the proceedings were opened by L. Zerzog, engineer, of Munich, who spoke on the "Valuation and Examination of Foundry Coke." The afternoon of the same day was spent in visiting the German Museum, under the guidance of Herr Orth, engineer, an official of the German Museum; whilst in the evening the members, with their wives and guests, met at the Franziskanerkeller for a real Bavarian "beer night."

On the following day two addresses were given: one by Dr. Klingenstein, of Zuffenhausen, on "Desulphurisation in the Cupola Furnace, with special reference to Fluorspar"; and the other by Professor Behr, of Berlin, on "The Structure of Clay for Cupola Furnaces." This, as also all the other addresses, gave rise to extremely long and animated discussions amongst those present. In the afternoon of the same day the German Transport Exhibition was inspected.

The general meeting proper was held on the Sunday. It was opened with an address of welcome by the President, Dr. Dahl, in which he cordially thanked for their support the representatives of the Munich Municipality, the Government authorities, technical high schools and mining colleges, as also the technical associations, but, particularly, His Excellency Oscar von Miller. The President then gave a lengthy survey of Germany's economic position, which was followed by a lengthy report on the Association's activity during the past financial year. Then two more addresses were submitted—Professor Diepschlag, Breslau, speaking on "Refining of Cast Iron," and Dr. Claus, Meerane, on "Deoxidation Processes and Deoxidising Agents for Non-Ferrous Metal Melting." A banquet was given at the "Bayerischer Hof" Hotel, the members and their friends remaining until a very late hour.

The official arrangements were concluded on Monday by a motor drive to the Walchensee Works, which were inspected by the party.

We append below abstracts of the Papers read:—

The Valuation and Testing of Foundry Coke.

By Chief Engineer Zerzog.

[*Extract.*]

To facilitate an evaluation of foundry coke a comparison of Rhenish-Westphalian, Zwickau and Lower Silesian foundry cokes was carried out. The most exhaustive tests were made in the laboratory and foundry, and it was found that foundry coke requires a longer carbonisation period than blast-furnace coke and that the combustibility of the coke is the determining factor as regards its quality. It was specially pointed out that there is no connection between porosity and combustibility in coke.

In the lecture, apparatus was shown enabling the permeability of the coke to gas, as well as its combustibility, to be determined.

The author's observations also touched upon the standards for foundry coke recently formulated by Herr H. Koppers.

The question of sulphur was also specially referred to in connection with the Sulphur Sub-committee of the Coke-works Committee formed with reference to this subject. It was suggested that the sulphur content should be reduced by the addition of fluorspar or by employing the well-known desulphurisation processes of the Esslingen Engineering Works, or of Rein-Dürkopp & Walter. Attention was also drawn to the sampling of coke and the sources of errors in the process.

The question of the appearance of coke was specially examined in a series of illustrations, which showed that an ocular examination very frequently leads to erroneous conclusions.

By means of parallel heats with different kinds of coke attention was drawn to the proper supply of the blast to the cupolas. A detailed account was also given of the effects of coke ash.

Desulphurisation in Cupolas, with Special Reference to Fluorspar.

By Dr. Klingenstein.

[*Extract.*]

A great deal, Dr. Klingenstein remarked, had recently been said about the refining of cast iron. Many regarded its desulphurisation and degasification as part of the refining process. Here, however, it was necessary to differentiate strictly between purification and refining.

The object of purifying cast iron must be to free it from foreign bodies which are unnecessary for the formation of the structure of the material or are detrimental to it, while the refinement of cast iron must improve its structure typically. Sulphur had always been regarded as the most dangerous foreign body from which cast iron has to be purified, although no doubt its effects were often not so far-reaching as the expert imagined. In the problem of desulphurisation the question must first be faced: "How, in the first place, can as low a sulphur content as possible be obtained in the charge, and how, by controlling the quality of the pig and of the coke, can an iron with the lowest possible sulphur content be cast?

In this connection the Siegen pig-irons were specially determinative owing to their high sulphur content. They require a high degree of sulphur removal in melting owing to their high manganese content and their already high sulphur content *per se*. Efforts should therefore be made to effect the supply of manganese by means of lower Mn contents in the pig-iron. The Esslingen Engineering Works had for these reasons introduced their manganese blocks, which permitted of manganese being added without sulphur removal. It was well known that the sulphides are present in the iron, partly as iron, partly as manganese sulphide, and partly as a mixture of both together. The melting diagrams of these systems showed how by suitable Mn additions in the form of Mn-sulphide or a sulphide mixture rich in Mn-sulphide a natural desulphurisation was effected. It must be the task of the ironfounder to facilitate absorption of the separated sulphides by regulating the slag formation. The solubility of the slag as regards sulphides was, however, determinatively dependent on the amount of silica in the slag, *i.e.*, on the lime content. The question whether this lime content should be supplied by fluorspar or by limestone had already been discussed by the author in an address given at the South German Conference in Ulm and published in No. 11 of the "Giesserei Zeitung." A repetition of these experiments, in which both slag and the furnace lining burnt off from the brickwork were calculated according to the Osann method, gave as regards fluorspar the results already described in the journal mentioned. No diminution in sulphur took place; with an increase of the fluorspar addition the accumulation of slag and the waste from the brickwork increased as follows:—

	Amount of slag. Per cent.	Waste from furnace lining. Per cent.
(1) Normal limestone addition	7.32	2.3
(2) ⅓ fluorspar addition	7.22	2.29
(3) ⅔ fluorspar addition	8.29	4.11
(4) Pure fluorspar addition	9.41	4.11

Dr. Klingerstein showed how even with chemical desulphurisation the Mn content must play a part which, moreover, must operate where natural desulphurisation was impossible owing to a low Mn content—for example, in malleable castings and merchant iron, in which the question of price was important. The most widely adopted process

of chemical desulphurisation was the "Dürkopp-Luyken-Rein process. Of this a brief description was given.

The address was illustrated by numerous slides showing the types of structure discussed, as well as the figures quoted.

The Structure of Clays for Cupola Furnaces.

By PROFESSOR BEHR.

[*Extract.*]

After some introductory remarks relating to the plastic clay system in general, the speaker discussed the working programme of the Committee for the Investigation of Cupola Furnace Bricks and Clays. In addition to investigations made in practical working, various clays were, at his suggestion, tested by ceramic methods partly in the Chemical Laboratory of the Prussian National Geological Institute, partly in the Chemical Laboratory for the Clay Industry (Professor Seeger and C. Cramer) in Berlin. The refractory bricks which had done good service in the iron foundry constituted the standard for testing clays. The raw materials (clays and quartzites) and their properties were then discussed, as well as the importance of testing as to refractoriness and heat resistance, the importance of chemical and mechanical analyses, stability, permeability to gas, porosity and structure. A table of analyses giving the results of investigations carried out with 9 different puddled clays, which was presented to the audience, gave a clear idea of their highly differentiated composition, in which partly artificial mixtures, partly natural ingredients, are employed. The structure of burnt and unburnt clays was elucidated by several helios and photographs of photomicrographic preparations. The comparative table, in conjunction with practical experiments, showed how defects still existing in the composition might be eliminated. Various samples of clays were also submitted by the speaker.

Deoxidation Processes and Deoxidising Agents for Non-Ferrous Metal Meltings.

By DR. WILLI CLAUS.

[*Extract.*]

Starting with the physical, physico-chemical and purely-chemical properties of a melt its individual alloy-components and every oxide possible, the speaker subdivided the meltings of non-ferrous metal alloys into *self-deoxidising melts, i.e.*, melts which theoretically require no treatment whatsoever by deoxidising agents, and melts containing oxide.

Since the finished castings produced from auto-deoxidising melts must show no porosity of any kind due to oxide inclusions, which, however, was by no means always the case, all melts necessarily underwent, outside the crucible, i.e., during casting, a secondary oxidation, to which this undesirable phenomenon was due. The speaker believed he had found the location of this oxidation in that portion of the out-flowing stream of metal which was situated between the separated layer of slag remaining in the crucible and the liquid metal accumulating in the mould. On closer examination of various self-deoxidising melts which permitted of being cast free of pores, and of those which could be similarly cast only with very great difficulty (variations of temperature) it was found that the former alloys invariably contained a constituent which, at casting temperature, possessed a considerable steam-tension (Zn, Pb), the oxide of which, therefore, in the part of the metal stream referred to, was not produced *on* the melt—where it could be entrained by adhesion—but *above* the stream, *in the air*. Thus an excellent protection was afforded to the stream by a readily oxidisable film of steam.

These examination results were utilised by Dr. Claus to formulate more extensive requirements with regard to deoxidising elements for non-ferrous metal alloys than those usually expected.

He then discussed in detail all the deoxidation processes in melts of alloys with heavy or light metal as base, and examined critically the process which has recently been put forward, namely to deoxidise . . . . aluminium-containing melts of alloys with copper base only after thorough oxidation by copper oxide, by means of phosphor copper.

In the second part of his Paper the author enumerated (and discussed in part) all the deoxidising agents at present known for non-ferrous metal alloys, with special reference to the group of deoxidation alloys introduced by him for the first time in the deoxidation art, in which the alloy-component having a non-deoxidising effect is a metal which will not combine with the melt to be deoxidised. As a typical example of this intermediate group of alloys, he spoke with general reference to the very great cheapness of such products, on lead phosphide, first produced and patented by him in Germany.

The Paper concluded with a summary of all the given data, while laying down fundamental rules for the selection of suitable de-oxidising agents for all non-ferrous metal meltings.

Book Review.

Manganese Ore, with Special Reference to Georgian Ore, by Datico Zereteli. Published by The Dryden Press, 8, Frith Street, Soho Square, London, W.1. Price 8s. 6d.

With the advent of mixing to analysis in foundry practice, a number of iron foundries stock ferro-manganese, and as this continues it will help to use up more quickly the already limited supplies of manganese ore. As the author points out, production is scarcely up to consumption. One of the most potent factors in the market is the Georgian (Russia) deposits. Actually in 1913 it was the largest source, when it raised 1,066,600 tons. This dropped in 1921 to a paltry 25,520 tons, but each year since it has grown until last year when 480,795 tons were produced. From 1913 to 1924 the world's consumption of ferro-manganese dropped by ⅓, during which time the output of steel remained almost stationary.

Whilst the author has chosen to emphasise Georgian ores in his title, it must not be assumed that this takes up the major portion of the book, actually only Chapter VI is devoted to the subject, a matter of 30 pages out of 136. For some curious reason Georgian manganese ore has been known as Caucasian, instead of a general Transcaucasion or more particularly Georgian, as there happens to be two other countries in Transcaucasia. At the moment there is something fascinating about the manganese market, with the Georgian and Gold Coast materials as "dark horses." It is of interest to note that last year 45 per cent. of the American import of manganese ore came from Georgia, the balance, of course, would be from Brazil, India and possibly the Gold Coast.

Those of our readers who, as they should, take an interest in the economics of their industry, should closely study this book. It is interesting to note that according to the author the earnings of the miners in Georgia are less than in 1913.

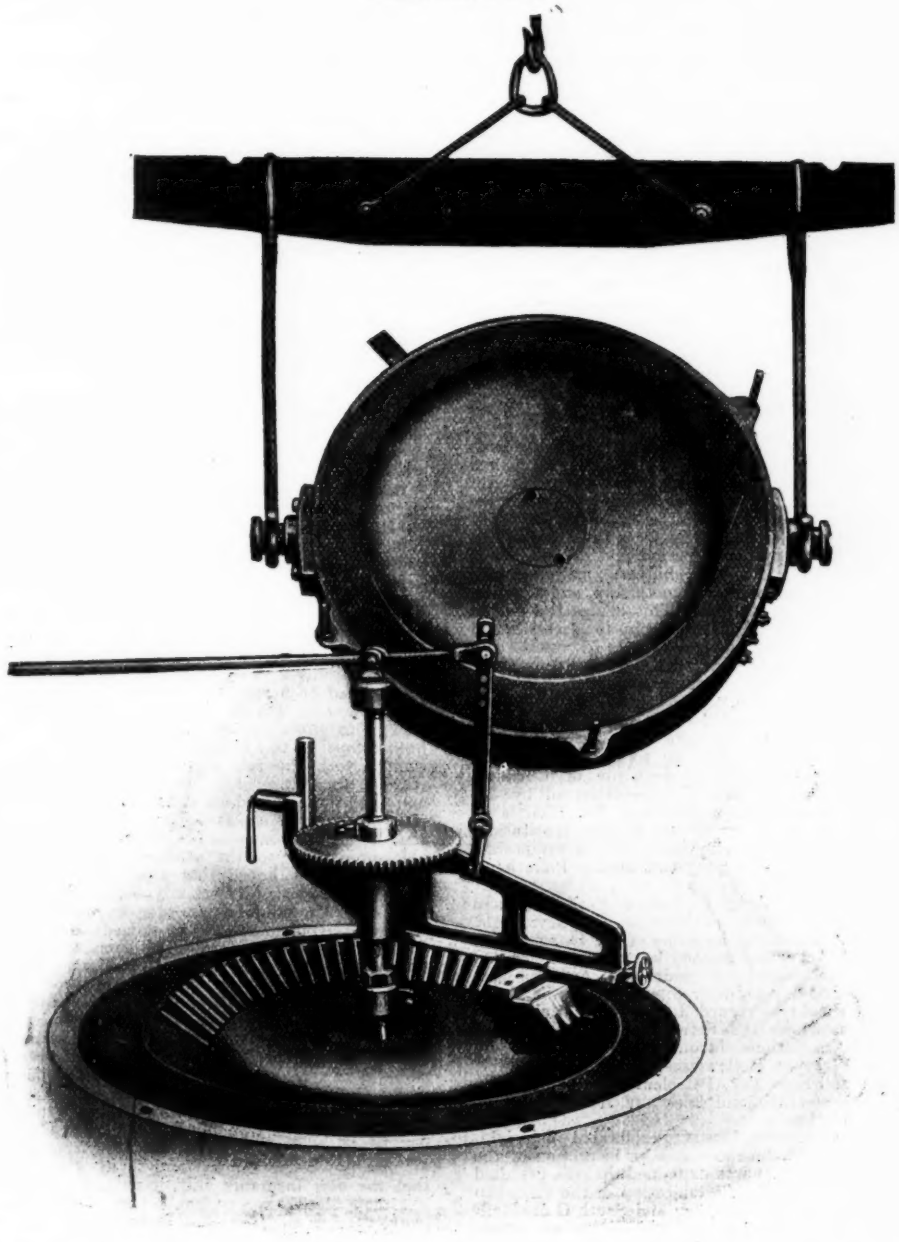
A factor in the manganese ore market since 1916 has been the Gold Coast, where the production has risen from 4,258 tons in 1916 to 255,647 last year. This is the ore which is being smelted in Norway.

Association of Special Libraries and Information Bureaux.

This Association has been formed with the object of facilitating the co-ordination and systematic use of sources of information in science, industry, commerce and public affairs. The chairman of the committee is Mr. J. G. Pearce, the Director of the B.C.I.R.A. He, together with Dr. Hutton, of the Non-Ferrous Research Association, were the first to realise the necessity of such an organisation, and it is due to their efforts that one has been formed. A meeting was held last September, and its Proceedings are now available at a cost of 3s. 6d. A second conference is to be held at Balliol College, Oxford, from September 25 to 28, particulars of which are available from Mr. Guy W. Keeling, the organising secretary, at 38, Bloomsbury Square, London, W.C.1.

The "VULCANIA" PATENT WHEEL MOULDING MACHINE.

Patent No. 5049.



THE "VULCANIA" PATENT WHEEL MOULDING MACHINE is for moulding spur wheels with straight, sloping or Vee-shaped teeth, also bevel wheels, skew gear wheels, worm wheels and internal wheels. The machine head is carried on a pillar which is held in a base-plate bedded in the floor sand, and is made to slide on the pillar by means of a lever and link carried on a joint bearing, or by rack and pinion, or screw if thought advisable for the particular work it is being used for.

An adjustable stop collar is provided for accurately deciding the depth of mould. On the removable head a slide is carried for supporting the patterns of the teeth to be moulded. This slide is made adjustable by screw or pinion gearing to the diameter required. The number of teeth to be moulded is decided by a special dividing plate into which a steel wedge or finger engages. The special dividing plate has milled vees, at the angle of 60° inclusive, around its circumference, to receive the steel wedge, which is adjusted by a screw having an internal spring to keep it in tension and to lock the head when ramming operations are being carried out.

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Trade Talk.

BALDWIN'S, LIMITED, damped down their furnace on basic at the Swansea Hematite Iron and Steel Works, Landore, Glam., on June 27.

A LICENCE under the Non-Ferrous Metal Industry Act, 1918, has been granted by the Board of Trade to Brocard, Speiser & Company, Limited, 21, Mincing Lane, London, E.C.3.

THE CONSETT IRON COMPANY, LIMITED, damped down one furnace on June 25, and now have four in blast out of a total of eight furnaces. One furnace is partially demolished.

WM. BEARDMORE & COMPANY, LIMITED, have an order from the London County Council for a sludge-carrying steamer. The vessel will be 250 ft. in length, 43 ft. 6 in. in breadth, and 15 ft. 10 in. in depth.

THE average net selling price of No. 3 Cleveland pig-iron for the second quarter of the year has been certified at 76s. 3.12d. per ton, as compared with 78s. 6.87d. for the previous three months, and under sliding scale arrangements North-East Coast blast-furnacemen's wages are reduced by 3½ per cent.

COX & DANKS, LIMITED, have raised the 14th German destroyer at Scapa Flow. It was the G 39, and was lying on its side, propped up across the G 86. The two ships had to be disengaged on the bottom of the sea by divers before the G 39 could be brought to the surface. The whole operation was carried out in less than one week.

DURING the first six months of this year ten vessels were launched from the Belfast shipyards, as against seven for the corresponding period last year. Two of the ten, however, were merely barges, so that the output substantially consists of eight ships of 34,000 tons. The output is the lowest for a first half of the year for a very lengthened period.

THE output from the Wear shipyards at Sunderland during June was two vessels, a motorship, and a collier, aggregating 7,070 gross tons. This brings the output for the first six months of the year up to 14 vessels and 53,616 gross tons, as compared with 33 vessels and 109,378 gross tons in the first half of 1924. Only seven of the 53 berths on the river are occupied with ships in course of construction.

THE ANNUAL MEETING of the Institution of Chemical Engineers this year will take place at Leeds, on Friday, July 17. This will be followed by a joint meeting with the American Institute of Chemical Engineers, when addresses will be delivered by the president of the American Institute, Dr. Charles L. Reese, and the president of the British Institution, Sir Arthur Duckham, following which a symposium on "Industrial Water Supply and Stream Pollution" will be presented.

THE QUESTION of bringing before Parliament and the country the urgent necessity of simplifying the procedure and widening the scope of the Safeguarding of Industries Act was discussed last week at Birmingham by representatives of industrial organisations. They asked that any industry coming under the Trade Boards Act should be regarded as a substantial industry and come under the Safeguarding of Industries Act. The Associations favouring the proposal included the Wrought Hollowware, Brazed Brass Tube, Hand Tool and Steel Toy, Petroleum Lamp and Stove, Sheet Metal, and Midland Lock and Latch Manufacturers' Association.

JOHNSON & PHILLIPS, LIMITED, celebrated their jubilee on July 3, by a luncheon and an inspection of the works at Charlton. It was explained that the firm had been identified with the electrification of the suburban branch of the London, Brighton and South Coast Railway; that they were now engaged in the electrification of the South-Eastern section of the Southern Railway, and that for a half-century their activities had been directed to pioneering enterprises in connection with the manufacture of cables, transformers and electric gear generally. The works at Charlton, which began in one small building, now cover an area of fifteen acres. The profits last year amounted to about £160,000, and there was a reasonable prospect of its being increased this year.

MCCLELLAND KER & COMPANY, in a report to the shareholders of Hawthorn & Company, engineers and shipbuilders, Leith, recall that they were consulted by the directors in May, 1924, as to what action should be taken with a view to avoiding liquidation. Subsequently certain assets of the company were disposed of, the Victoria Shipyard, Leith, and stocks therein, realising £27,000. An offer was then put forward with regard to unsecured creditors, the consent of the secured creditors being obtained on certain conditions. This has enabled the retention of the main assets of the company in the hope that trade conditions may improve and that the works can ultimately be restarted or sold at a better price than would be obtainable at present. The amount due to secured creditors, who are now the only creditors of the company, amounts to £58,788.

Company News.

Associated Equipment Company, Limited.—No interim dividend.

Greenwood & Batley, Limited.—Dividend, 2½ per cent., making 5 per cent. for year.

Richard Thomas & Company, Limited.—Interim dividend on ordinary shares passed.

Philip & Bruce (Metals), Limited.—Capital £2,000 in ordinary £1 shares. Metal merchants.

Allen-Liversidge, Limited.—Dividend, 7½ per cent., (less tax), making 12½ per cent. for the year.

Ripon Steel Company, Limited.—Capital £5,000 in £1 shares. Directors: H. R. Wilson and J. H. Wilson.

Climax Furnace (London), Limited.—Capital £1,000 in £1 shares. Engineers. Directors: E. Shortt, K.C., 104, Oakwood Court, W.14; Earl of Drogheda and J. A. Hope.

Chas. Haley & Company, Limited, Diamond Street Foundry, Bradford.—Capital £4,000 in £1 shares. Ironfounders. Directors: C. Haley, Mrs. M. H. Haley and N. W. Green.

Dumfries Peco, Limited, 47, Victoria Street, Westminster, London, S.W.—Capital £110,000 in £1 shares. Engineers. Directors: Major the Hon. Edward Lascelles and Miss Treetup.

Mond Nickel Company, Limited.—Net profit, £29,387; brought forward, £40,403; total, £337,790; preference dividend, £175,000; dividend on ordinary shares, 12½ per cent., £112,500; carried forward, £50,290.

Consett Iron Company, Limited.—Trading conditions during the past year grew steadily worse, said MR. C. D. SMITH, chairman of the Consett Iron Company, Limited, presiding at the annual meeting, held in Newcastle, recently. There was to-day practically no demand for iron, steel, coal or coke, and, notwithstanding the utmost efforts of their management and sales department, it was almost impossible to effect any sales of their products at prices which showed any profit whatever, and, in the case of coal in particular, the result was a substantial loss. Although the price of coal had been reduced, and was far below the cost of production, it was not, even now, apparently low enough to stimulate an increased demand. They had been compelled to suggest to their employees that they should work the full hours of seven bank to bank without the extra twenty minutes permitted by law, and that there should be substantial reductions in the piece-work prices so as to bring the wages cost per ton down to an amount which would bear a reasonable proportion to the selling price. It was most earnestly to be hoped that a satisfactory settlement would be reached. It certainly could not be said that the company, as soon as the depression was felt, sought to avoid losses by the immediate closing down of the collieries concerned. The cumulative effects on industry of the heavy rise in labour costs, direct extra cost over pre-war per unit of production due to the serious increase in the burden of Imperial and local taxation, added to the difficulty of meeting competition with the increased cost of transport, was gradually bringing to a stand the manufacturing concerns in this country. Particularly in the heavy steel trade, the costs of manufacturing were increased very materially by the partial employment of the plant owing to lack of trade, and this could only be met by safeguarding our staple industries from the effects of unfair foreign competition. When he told them that the new Insurance Bill, if passed, would add to less than £12,000 per annum to the costs of that company, they would appreciate the necessity of a protest being made against extra burdens being put on industry at present. National and local economy was imperative.

Personal.

MR. G. SALTER, a director of T. E. Salter, Limited, ironfounders, Tipton, has been chosen as the prospective Liberal candidate for the Bilston Division.

MR. H. W. BAINBRIDGE, of Southcroft, Stratford-on-Avon, iron and steel merchant, has been placed on the Commission of the Peace for the County of Warwick.

Wills.

JACOB, A., of Merrow, The Avenue, Hatch End, Middlesex, manager of the British Aluminium Company, Limited £4,465

CLOUGH, J., of Whitfield House, Whitcliffe Road, Cleckheaton, Yorks, iron merchant £4,534

ELLISON, J., for nine years engineer-in-chief with the Ebbw Vale Steel, Iron and Coal Company, Limited £7,843

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The STEEL COMPANY OF SCOTLAND, Ltd.

Head Office: 23, ROYAL EXCHANGE SQUARE, GLASGOW.
Works: HALLSIDE, NEWTON and BLOCHAIRN, GLASGOW.

CONTRACTORS TO HOME, COLONIAL AND FOREIGN GOVERNMENTS.

Established 1872. *Telegraphic Address: "Steel, Glasgow."*

IRON AND STEEL MARKETS.

Pig-iron.

MIDDLESBROUGH.—As is usually experienced at the turn of midsummer, business in the Cleveland iron market is restricted in scope, with buying on home account almost entirely confined to small parcels to meet immediate necessities only. The most disturbing element in the market at the moment is the crisis in the mining industry, with its threatening consequences of a national stoppage, but, so far, market opinion is optimistic that some adjustment of the difficulty will be found to avert the serious results of a suspension of industrial activity. In the meantime, prices continue irregular, makers quoting 71s. 6d. per ton for No. 3 G.M.B., with No. 1 about 75s. 6d., No. 4 foundry 70s. 6d., and No. 4 forge 70s. per ton.

In the Tees-side hematite market conditions remain much the same as last reported, but with restricted outputs makers are reducing the accumulated stocks of the past few months. Prices, however, do not yet show any indication of stability. About 77s. is the general quotation for East Coast mixed numbers, while No. 1 is quoted at 77s. 6d. per ton. In the North-West area prices again indicate a downward tendency, with Bessemer mixed numbers quoted at £4 5s. c.i.f. Welsh ports, £4 8s. 6d. per ton delivered at Glasgow, £4 12s. 6d. per ton delivered at Sheffield, and £4 15s. per ton delivered at Birmingham.

LANCASHIRE.—Conditions in the local markets for foundry pig continue inactive, with few signs of early relief from the present stagnation. Prices, too, remain uncertain, some of the Derbyshire furnaces quoting 70s. per ton on trucks for No. 3, and some 71s. and 71s. 6d. At the lower price iron can be delivered in Manchester at 77s. 6d. per ton, and business has been done at that figure; but one does not yet hear of any large contracts being made for delivery over the remainder of the year.

THE MIDLANDS.—At Birmingham last week movements in foundry pig were again confined to dealings on a limited scale, with very little doing on forward account. There has been no alteration in the prices of foundry pig-iron, although figures now given must be considered weak, and concessions would undoubtedly be obtainable for offers of definite business. The furnaces have too large a stock and too small an order book to turn away offers, and further reductions are regarded as inevitable. Ruling prices are as follow :—Derbyshire No. 3 foundry, 70s.; Staffordshire No. 3 foundry, 72s. 6d.; Northants. No. 3 foundry, 65s.

SCOTLAND.—The approach of the northern holiday season has had its usual quietening effect upon the Scotch pig-iron markets, with business practically at a standstill, while it is difficult to say exactly what prices are in the absence of dealings. Nominally Scotch No. 3 foundry is quoted at 81s. 6d. at the furnaces, but no doubt for definite business down to 80s. would be possible

Finished Iron.

Makers of this class of material still complain of an insufficiency of orders to keep plants fully employed, with the exception of the marked bar manufacturers, who, it is reported, are in a somewhat better position as concerns specifications, which are coming forward in bigger tonnage than of late. The price remains at £14 10s. f.o.r. makers' works, and there are no indications of any reduction. This is the best employed section in the Staffordshire trade. It is the maker of the cheaper iron who finds the greatest difficulty. Here the manufacturers have to contend with the French and Belgian competition, which at present is very severe. This foreign product is being offered at £6 10s. to £6 12s. 6d. delivered this area, a figure nearly £5 per ton cheaper than the Staffordshire nut and bolt iron. As a matter of course, the bulk of the Darlaston trade must go abroad. Local crown quality iron bar quotations are £12 7s. 6d. per ton delivered, but it is possible to buy from outside the Association at a shilling or so less than this.

Steel.

At Sheffield the steel market is quiet and sales of both acid and basic billets are very small. Business in railway and motor-car steel is on a better scale, while axle, spring, and tyre plants are well engaged, and file makers are very busy. Crucible steel is still quiet, and open-hearth steel manufacturers report very little new business. Scottish steel sheet-makers are obtaining a fair amount of business, chiefly for export in thin gauges. The home demand is somewhat slow, and heavy gauges are scarce. Prices remain unchanged. The inquiry for tinplates is only very moderate, and buyers' ideas of values are exceedingly low, 19s. 3d. having been accepted in several instances, but this quotation is not general, most makers holding out for a higher figure.

Scrap.

Very little change for the better can be reported in the markets for scrap metal, buying being more and more restricted each week, with prices correspondingly weaker as the depression increases. In Lancashire the demand for scrap on foundry account is only limited, consumers only offering 72s. 6d. for ordinary broken machinery iron, although dealers are able to obtain quite a good price for cast-scrap from looms, and up to 82s. 6d. is paid for it, while some holders try for 85s. per ton. It is not often that this special scrap will bring 10s. more to the seller than good ordinary broken machinery; but of the latter there is plenty on the market. In Scotland, machinery cast-iron scrap, suitable for foundries, is weak, as consumers are using very little at the present time. The same applies to ordinary quality. The current prices are 80s. per ton, and 72s. 6d. to 75s. per ton respectively. Old cast-iron railway chairs have again been sold at 79s. per ton, but the demand is also poor. Light cast-iron scrap and firebars are in poor demand and some small lots have actually been bought at 55s. per ton. The above prices are all per ton, delivered f.o.t. consumers' works.

Metals.

Copper.—Renewed activity has been a recent development of business in this section of the market, while values have also resumed normal levels and the tone throughout has been remarkably steady. It may be noted that the recent set-back in copper values was not due to any change in the technical position of the commodity which remains perfectly sound, but it was due to outside influences such as the weakness in the franc, the unsettled state of industry in this country and somewhat weaker American advices. Current quotations :—*Cash* : Thursday, £61 12s. 6d.; Friday, £61 5s.; Monday, £61 12s. 6d.; Tuesday, £61 15s.; Wednesday, £61 17s. 6d.

Three Months : Thursday, £62 12s. 6d.; Friday, £62 5s.; Monday, £62 12s. 6d.; Tuesday, £62 15s.; Wednesday, £62 17s. 6d.

Tin.—Consideration of the slightly more favourable statistical position, values of standard tin have developed a firmer tendency, with a fair volume of sales recorded both for home and shipment abroad.

Tin stocks, landing and afloat in Europe and America at the end of June, according to Ricard & Freiwald's statement, amounted to 19,414 tons, as against 19,499 tons for May, showing a decrease in the total visible supply of 85 tons. Monthly supplies from all sources amounted to 10,354 tons, as against 11,037 tons for the previous month deliveries in that period being 10,439 tons, as against 8,363 tons for May. Current quotations :—*Cash* : Thursday, £258 5s.; Friday, £257 5s.; Monday, £258 5s.; Tuesday, £260 5s.; Wednesday, £259 7s. 6d.

Three Months : Thursday, £260; Friday, £258 15s.; Monday, £260 5s.; Tuesday, £262 10s.; Wednesday, £261 10s.

Spelter.—A somewhat harder tendency in values of this metal has been recorded over the past week due to some bear covering, but the position generally is quite colourless. Stocks are on the increase and the outlook is very uncertain. In view of the dulness in the consuming trade one is inclined to look for lower prices for zinc over the next week or two, and at the moment the position is absolutely featureless. Current quotations : — *Ordinary* : Thursday, £34 13s. 9d.; Friday, £34 10s.; Monday, £34 16s. 3d.; Tuesday, £34 16s. 3d.; Wednesday, £34 13s. 9d.

Lead.—The market for soft foreign pig has been firmer on the whole, but no great confidence is expressed in the position, and the usual speculative manipulation has been absent. Pig lead at present prices must be regarded as very high; thus the future is very uncertain, and as is pointed out the danger of buying metal at current rates beyond immediate requirements is obvious. Current quotations :—*Soft foreign (prompt)* : Thursday, £34 2s. 6d.; Friday, £34 5s.; Monday, £34 8s. 9d.; Tuesday, £34 7s. 6d.; Wednesday, £34 7s. 6d.

BLACKING,
PLUMBAGO,
CORE GUM,
WHITE DUST,
COAL DUST.

ESTABLISHED 1863

JAS. DURRANS & SONS, LTD.

PHOENIX WORKS, PENISTONE, near SHEFFIELD.

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Manufacturers of

FOUNDRY EQUIPMENTS

LADLES,
FIRE BRICKS,
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CASTING CLEANERS,
PIPE NAILS,
SPRIGS,
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LOAM AND SAND MILLS,
STUDS,
CHAPLETS,
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SPADES, Etc.

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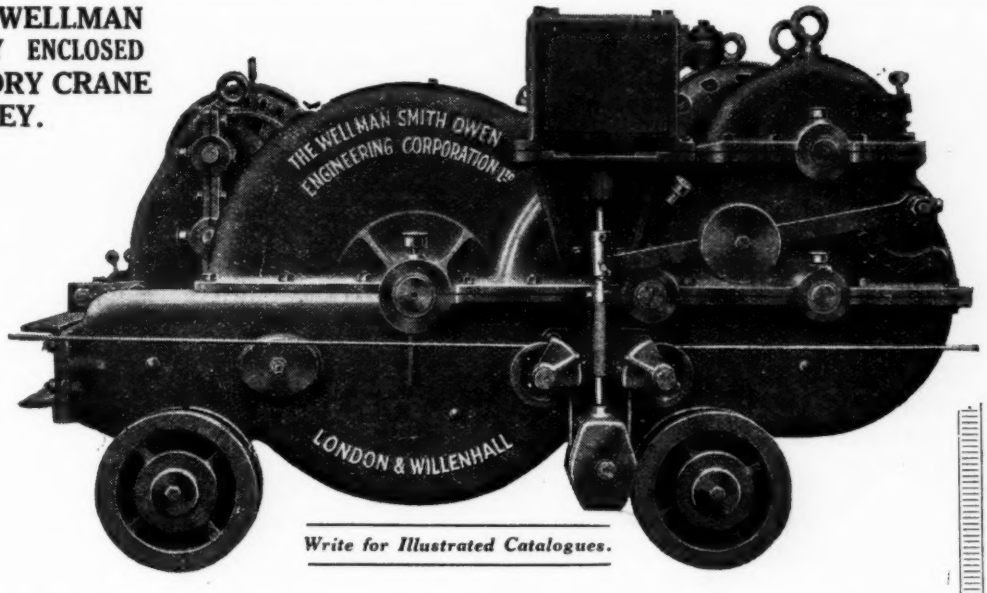
THE WELLMAN TOTALLY ENCLOSED FOUNDRY CRANE TROLLEY.



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ELECTRIC FOUNDRY CRANES

Our Standard Electric Overhead Travelling Cranes have been designed primarily to meet the requirements of Iron and Steel Foundries. All gears are totally enclosed, ensuring long life under arduous working conditions in the Foundry atmosphere full of dust and grit. All parts are interchangeable. Replacements from stock.

THE WELLMAN SMITH OWEN ENG. CORP. Ltd.

TELEPHONES: Holborn 2588/9.

36-38, Kingsway, LONDON, W.C.2.

WORKS :: :: DARLASTON, S. Staffs.

TELEGRAMS: "Principium, Westcent, London."

WEEKLY PRICE CURRENT.

COPPER.

	£	s.	d.
Standard cash	61	17	6
Three months	62	17	6
Electrolytic	66	0	0
Tough	63	0	0
Best selected ..	63	10	0
Sheets	90	0	0
India	78	0	0
Wire bars ..	66	0	0
Do. July ..	65	10	0
Do. July ..	65	10	0
Ingot bars ..	65	10	0
H.C. wire rods	69	10	0
Off. av. cash, June	59	19	2¾
Do., 3 mnths., June	60	18	9
Do. Sttlmnt, June	59	18	9½
Do., Electro, June	63	11	5½
Do., B.S., June	63	1	11½
Aver. spot price copper, June	59	19	2¾
Do., wire bars, June	63	15	5½
Solid drawn tubes			13d.
Brazed tubes ..			13d.
Wire			10d.

BRASS.

Solid drawn tubes	11¾d.
Brazed tubes ..	13¾d.
Rods, drawn ..	10¾d.
Rods, extd. or rlld.	7¼d.
Sheets to 10 w.g.	10¾d.
Wire	9¾d.
Rolled metal ..	9¾d.
Yellow metal rods	7¾d.
Do. 4 x 4 Squares	8d.
Do. 4 x 3 Sheets	8¼d.

TIN.

	£	s.	d.
Standard cash	259	7	6
Three months ..	261	10	0
English ..	259	10	0
Bars	262	10	0
Straits	266	0	0
Australian ..	265	0	0
Eastern ..	266	0	0
Banca	266	10	0
Off. aver. cash, June	252	11	8
Do., 3 mths., June	253	19	8¾
Do., Sttlmnt. June	252	12	7¾
Aver. spot., June	252	11	8

SPELTER.

Ordinary ..	34	13	9
Remelted ..	34	10	0
Hard	29	10	0
Electro 99.9 ..	39	7	6
English ..	35	5	0
India	31	0	0
Zinc dust ..	42	0	0
Zinc ashes ..	14	10	0
Off. aver., June	33	17	4 13/16
Aver., spot, June	34	2	11¾

LEAD.

Soft foreign ppt.	34	7	6
English ..	35	15	0
Off. average, June	33	4	6 5/16
Average spot, June	33	9	7

ZINC SHEETS, &c.

Zinc sheets, English	40	0	0
Do. V.M. ex whf.	40	0	0
Dutch			—
Rods	46	0	0
Boiler plates ..	40	0	0
Battery plates	39	0	0

ANTIMONY.

Special brands, Eng.	84	10	0
Chinese ..	65	0	0
Crude	51	0	0

QUICKSILVER.

Quicksilver ..	14	0	0

FERRO-ALLOYS AND STEEL-MAKING METALS.

Ferro silicon 45/50% ..	13	0	0
75%	22	5	0
Ferro-vanadium— 35/40% ..	16/6 lb. va		
Ferro-molybdenum— 70/75% c. free	7/- lb.		
Ferro-titanium— 23/25% carbonless	1/- lb.		
Ferro-phosphorus, 20/25%,	£22	0	0
Ferro-tungsten— 80/85 %, c.fr. 1/5 to 1/5½ lb.			
Tungsten metal powder— 98/99%	1/9 lb.		
Ferro-chrome— 4/6% car. ..	£23	10	0
6/8% car. ..	£23	0	0
8/10% car. ..	£22	10	0
Ferro-chrome— Max. 2% car.	£42	10	0
Max. 1% car.	£52	0	0
Max. 0.70% car.	£56	10	0
70%, carbonless	1/5 lb.		
Nickel—99%, cubes or pellets	£170 to £175		
Cobalt metal—98/99%	10/-lb.		
Aluminium 98/99%	£118		
Metallic Chromium— 96/98% ..	3/9 lb.		
Ferro-manganese (net)— 76/80%, loose	£15	10	0
76/80%, packed	£16	10	0
76/80%, export	£15	0	0
Metallic manganese— 94/96%, carbonless	2/-lb.		

Per ton unless otherwise stated.

HIGH-SPEED TOOL STEEL.

	s.	d.
Finished bars, 14% tungsten ..	2	6
Finished bars, 18% tungsten ..	3	0

Per lb. net, d/d buyers' works.

Extras—

Rounds and squares 3 in. and over ..	4d. lb.
Rounds and squares under ½ in. to ¼ in.	3d. lb.
Do. under ¼ in. to ⅛ in.	1/- lb.
Flats, ½ in. × ¼ in. to under 1 in. × ⅛ in.	3d. lb.
Do. under ½ in. × ¼ in.	1/-lb.
Bevels of approved sizes and sections	6d. lb.

Bars cut to length 10% extra

Scrap from high-speed tool steel—

Scrap pieces ..	3d.
Turnings and swarf	1d.

Per lb. net, d/d steel makers' works.

SCRAP.

	£	s.	d.	£	s.	d.
South Wales— Hvy, steel	3	5	0 to	3	7	6
Bundled steel &shrngs.	3	2	6 to	3	5	0
Mixed iron & steel ..	3	0	0			
Heavy cast iron	3	5	0 to	3	7	6
Good machinery for foundries ..	3	15	0			
Cleveland— Heavy steel ..	2	17	6			
Steel turnings ..	2	6	0			
Cast-iron borings	2	2	6			
Heavy forge ..	4	0	0			
Bushelled scrap	3	7	6			
Cast-iron scrap ..	3	11	6			
Lancashire— Cast-iron scrap ..	3	15	0			
Heavy wrought ..	3	15	0			
Steel turnings ..	2	5	0			

London — Merchants' buying prices delivered yard.

Copper (clean) ..	52	0	0
Brass (clean) ..	39	0	0
Lead (less usual draft)	31	0	0
Tea lead ..	27	0	0
Zinc	24	0	0
New aluminium cuttings ..	92	0	0
Braziery copper	47	0	0
Gunmetal ..	47	0	0
Hollow pewter ..	165	0	0
Shaped black pewter	120	0	0

PIG-IRON.

(f.o.t. unless otherwise stated).

N.E. Coast— Foundry No. 1 ..	75/6
Foundry No. 3 ..	71/6
Foundry No. 4 ..	70/6
Forge No. 4 ..	70/-
Hematite No. 1 ..	77/6
Hematite M/Nos. ..	77/-
N.W. Coast— Hem. M/Nos. d/d Glas.	88/-
,, d/d Birm. ..	95/-
Midlands— Staffs. common* ..	102/-
,, No. 4 forge ..	70/-
,, No. 3 foundry	72/6
Shrops. basic ..	85/-
,, Cold blast, ord.*	190/-
,, ,, roll iron*	195/-
* d/d Birmingham.	
Northants forge ..	62/6
,, fdry No. 3 ..	65/-
Derbyshire forge ..	66/-
,, fdry No. 3 ..	70/-
,, basic	72/6
Scotland— Foundry No. 1 ..	86/6
,, No. 3 ..	81/6
Hem. M/Nos. ..	84/-
Sheffield (d/d district)— Derby forge ..	70/-
,, fdry. No. 3 ..	74/-
Lincs. forge ..	—
,, fdry. No 3 ..	78/-
E.C. hematite ..	87/-
W.C. hematite ..	92/6
Lincs. (at furnaces)— Forge No. 4 ..	—
Foundry No. 3 ..	72/-
Basic	72/-
Lancashire (d/d eq. Man.)— Derby forge ..	74/-
,, fdry. No. 3 ..	77/6
Northants foundry No. 3 ..	78/-
Dalzell, No. 3 ..	111/6
Summerlee, No. 3 ..	99/-
Glengarnock, No. 3	99/-
Gartsherrie, No. 3 ..	99/-
Monkland, No. 3 ..	99/-
Coltness, No. 3 ..	99/-
Shotts, No. 3 ..	99/-

FINISHED IRON AND STEEL.

Usual District deliveries for iron; delivered consumers' station for steel.

Iron—	£	s.	d.	£	s.	d.
Bars (cr.)	11	12	6 to	12	10	0
Angles		12	7	6		
Tees to 3 united ins		13	2	6		
Nut and bolt		11	15	0		
Hoops	14	0	0 to	15	0	0
Marked bars (Staffs.) f.o.t.		14	10	0		
Gas strip ..		13	0	0		
Bolts and nuts, ¾ in. × 4 in. ..		16	15	0		
Steel— Ship plates	8	15	0 to	9	0	0
Boiler plts.	£12	10	to	13	0	0
Chequer plts.	£10	10	to	11	0	0
Angles	£8	5	0 to	8	12	6
Tees	£9	5	0 to	9	12	6
Channels	£7	12	6 to	8	2	6
Joists	£8	5	0 to	8	12	6
Rounds and Squares 3in. to 5½in. ..		9	5	0		
Rounds under 3 in. to ¾ in.		9	0	0		
Flats, over 5 in. wide and up ..		9	15	0		
Flats, 5in. to 1½in.		8	15	0		
Rails, heavy ..		8	10	0		
Fishplates ..		12	10	0		
Hoops (Staffs.)	£11	0	0 to	11	10	0
Black sheets, 24g.		11	15	0		
Galv. cor. sheets, 24g.	16	0	0 to	16	5	0
Galv. fencing wire 8g. plain ..		14	0	0		
Billets, soft	6	10	0 to	7	15	0
Billets, hard ..		9	0	0		
Sheet bars	6	12	6 to	6	15	0
Tin bars d/d	6	12	6 to	6	15	0

PHOSPHOR BRONZE.

	Per lb.	basis.
Strip	1	2¾
Sheet to w.g. ..	1	3½
Wire	1	3½
Rods	1	2½
Tubes	1	7
Castings	1	2

Delivery 3 cwt. free.

10% phos. cop. £40 above B.S.
15% phos. cop. £50 above B.S
Phosphor tin (5%) £30 above price of English ingots.

C. CLIFFORD & SON, LIMITED.

NICKEL SILVER, &c.

	Per lb.
Ingots for raising	9d. to 1/3
Rolled— To 9 in. wide	1/3 to 1/9
To 12 in. wide	1/3½ to 1/9½
To 15 in. wide	1/3½ to 1/9½
To 18 in. wide	1/4 to 1/10
To 21 in. wide	1/4½ to 1/10½
To 25 in. wide	1/5 to 1/11
Ingots for spoons and forks	9d. to 1/5½
Ingots rolled to spoon size	1/- to 1/8½
Wire round— 3/0 to 10 G. ..	1/6½ to 2/1½

with extras according to gauge.

AMERICAN IRON & STEEL.

At Pittsburgh unless otherwise stated.	Dols.
No. 2X foundry, Phila.	21.26
No. 2 foundry, Valley	20.26
No. 2 foundry, Birm.	19.00
Basic	19.76
Bessemer	20.76
Malleable	20.26
Grey forge	19.76
Ferro-mang. 80% d/d	115.00
Bess. rails, h'y, at mill	43.00
O.-h. rails, h'y at mill	43.00
Bess. billets	35.00
O.-h. billets	35.00
O.-h. sheet bars ..	35.00
Wire rods	45.00
	Cents.
Iron bars, Phila. ..	2.22
Steel bars	2.00
Tank plates	1.90
Beams, etc.	2.00
Skelp, grooved steel ..	1.90
Skelp, sheared steel ..	1.90
Steel hoops	2.40
Sheets, black, No. 28 ..	3.10
Sheets, galv., No. 28 ..	4.15
Sheets, blue an'l'd, 9 & 10	2.30
Wire nails	2.65
Plain wire	2.50
Barbed wire, galv. ..	3.35
Tinplate, 100 lb. box ..	$5.50

COKE (at ovens).

Welsh foundry ..	37/6
,, furnace	27/6
Durham & North. ,, foundry ..	35/-
,, furnace ..	17/-
Other Districts, foundry	35/-
,, ,, furnace (Basis)	13/6

TINPLATES.

f.o.b. Bristol Channel ports.

I.C. Cokes,	20 × 14, box	19/4½
,,	28 × 20, ,,	38/9
,,	20 × 10, ,,	28/3
,,	18¾ × 14, ,,	20/3
C.W.	20 × 14, ,,	18/-
,,	28 × 20, ,,	35/6
,,	20 × 10, ,,	24/6
,,	18¾ × 14, ,,	18/4½

Terneplates 28 × 20, 1/3 per box basis below tinplates.

SWEDISH IRON.

Bars, hammered	£20/0 to £21/0
Rolled Ord.	£16/0/0 to £16/10/0
Nail rods	16 5 0 to £16 15 0
Keg. steel nom.	£33 to £35
Faggot steel nom.	£22 to £25
Blooms, according to quality	£10 to £14

Pig-iron £6 15 0 to £7 0 0 all f.o.b. Gothenburg.

TUBES.

	Up to and incl. 6 in.	
Gas	.. 55%	Tube prices are now free.
Water	.. 50%	
Steam	.. 45%	

DAILY FLUCTUATIONS.

Standard Copper (cash).

	£	s.	d.		
July 9	61	12	6	inc.	10/-
,, 10	61	5	0	dec.	7/6
,, 13	61	12	6	inc.	7/6
,, 14	61	15	0	,,	2/6
,, 15	61	17	6	,,	2/6

Electrolytic Copper.

	£	s.	d.		
July 9	65	10	0	inc.	10/-
,, 10	65	5	0	dec.	5/-
,, 13	65	5	0	No change	
,, 14	65	10	0	inc.	5/-
,, 15	66	0	0	,,	10/-

Standard Tin (cash).

	£	s.	d.		
July 9	258	5	0	inc.	45/-
,, 10	257	5	0	dec.	20/-
,, 13	258	5	0	inc.	20/-
,, 14	260	5	0	,,	40/-
,, 15	259	7	6	dec.	17/6

Tin (English ingots).

	£	s.	d.		
July 9	258	10	0	inc.	40/-
,, 10	257	15	0	dec.	15/-
,, 13	258	15	0	inc.	20/-
,, 14	260	10	0	,,	35/-
,, 15	259	10	0	dec.	20/-

Zinc Sheets (English).

	£	s.	d.		
July 9	40	0	0	No change	
,, 10	40	0	0	,,	,,
,, 13	40	0	0	,,	,,
,, 14	40	0	0	,,	,,
,, 15	40	0	0	,,	,,

Spelter (ordinary).

	£	s.	d.		
July 9	34	13	9	inc.	2/6
,, 10	34	10	0	dec.	3/9
,, 13	34	16	3	inc.	6/3
,, 14	34	16	3	No change	
,, 15	34	13	9	dec.	2/6

Lead (English).

	£	s.	d.		
July 9	35	5	0	No change	
,, 10	35	5	0	,,	,,
,, 13	34	8	9	dec.	16/3
,, 14	35	15	0	inc.	26/3
,, 15	35	15	0	No change	

AVERAGE MONTHLY PRICE OF IRON HOOPS.

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Yearly average.
	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.	£ s. d.
1896	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 2 6	6 5 0	6 10 0	6 3 4
1897	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0
1898	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 10 0	6 15 0	6 15 0	7 0 0	6 11 8
1899	7 0 0	7 0 0	7 0 0	7 0 0	7 12 6	10 12 6	8 12 6	8 12 6	8 12 6	9 2 6	9 7 6	9 17 6	8 2 6
1900	9 17 6	10 7 6	10 7 6	10 7 0	10 12 6	7 12 6	10 12 6	10 12 6	10 12 6	9 17 6	9 2 6	9 2 6	10 3 9
1901	9 2 6	8 2 6	8 2 6	7 12 6	7 12 6	7 12 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 11 8
1902	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6
1903	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6
1904	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6	7 2 6
1905	6 17 6	7 0 0	7 0 0	7 0 6	7 0 0	7 0 0	7 2 6	7 2 6	7 2 6	7 7 6	7 0 0	7 7 6	7 1 8
1906	7 10 0	7 17 6	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	7 15 0	8 7 6	7 15 10
1907	8 7 6	8 7 6	8 7 6	8 7 0	8 7 6	8 7 6	8 10 0	8 10 0	8 10 0	8 5 0	8 5 0	8 0 0	8 7 1
1908	8 0 0	7 10 0	7 10 0	7 10 6	7 10 0	7 10 0	7 10 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 6 8
1909	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0	7 0 0
1910	7 1 10½	7 6 3	7 7 6	7 7 0	7 7 6	7 7 6	7 7 6	7 7 6	7 7 6	7 6 3	7 5 0	7 5 0	7 6 5½
1911	7 5 0	7 5 0	7 5 0	7 5 6	7 5 0	7 5 0	7 5 0	7 5 0	7 5 0	7 8 9	7 10 0	7 10 0	7 6 1½
1912	7 12 6	7 12 6	7 12 6	7 15 0	7 15 0	8 2 6	8 2 6	8 2 6	8 12 6	8 12 6	8 12 6	8 15 0	8 2 3½
1913	8 17 6	8 17 6	8 17 6	8 17 0	8 17 6	8 17 6	8 17 6	8 7 6	8 7 6	8 7 6	8 7 6	7 17 6	8 12 6
1914	7 17 6	7 17 6	7 17 6	7 13 9	7 12 6	7 12 6	7 12 6	9 2 6	9 2 6	9 2 6	9 2 6	9 2 6	8 6 4½
1915	9 3 6	9 18 1	10 7 6	10 16 6	10 17 6	13 2 6	13 2 6	13 2 6	13 7 6	14 2 6	15 2 6	15 18 6	12 10 1½
1916	17 2 6	17 2 6	17 2 6	17 6 3	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 7 6	17 6 1½
1917	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6
1918	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6	17 2 6
1919	17 2 6	17 2 6	17 2 6	17 2 6	24 6 3	24 6 3	24 6 3	25 9 0	26 7 6	26 7 6	26 7 6	26 17 4	22 14 9
1920	28 0 0	28 12 6	33 15 0	35 5 0	35 15 10	38 17 6	38 17 6	38 17 6	38 17 6	38 17 6	36 17 6	36 17 6	35 14 9
1921	29 1 3	23 5 0	21 12 6	20 0 0	20 0 0	20 0 0	17 5 0	15 0 0	14 4 0	13 15 0	13 10 0	12 18 0	17 5 10
1922	16 5 0	15 13 9	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	14 0 0	13 4 6½
1923	14 0 0	15 0 0	15 0 0	15 0 0	15 6 0	15 0 0	15 0 0	15 0 0	15 0 0	15 0 0	14 16 0	14 15 0	14 18 3½
1924	14 15 0	14 15 0	14 15 0	14 15 0	14 15 0	14 13 9	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 12 4½
1925	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	14 10 0	—	—	—	—	—	—	—

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